

(45-5, A.2.)

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TUNING HEADS
MODELS RF-100 & RF-100A
Instruction Manual No. 110-5080

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INSTRUCTION MANUAL

TUNING HEADS,

MODELS RF-100 & RF-100A

Instruction Manual No. 110-5080

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The Singer Company, Palo Alto Operation

3176 Porter Drive, Palo Alto, California 94304/ (415) 493-3231 TWX 910-373-1765

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The Seller will not be liable for incidental or consequential damages. The Seller's sole liability shall be repair, replacement, or return of purchase price at our option. Warranty returns first must be authorized by the factory, and repairs or replacements (at our option) will be made without charge for instruments returned freight prepaid to the factory or authorized repair depot when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, batteries, fuses, lamps and transistors are excluded from Warranty coverage. If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, this warranty is VOID.

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|--|--|
| 1. Model or Type | 5. Description of trouble ⁽²⁾ |
| 2. Serial Number | 6. Has maintenance action been previously requested? |
| 3. Approximate date instrument was placed in operation | 7. Other comments |
| 4. Approximate number of hours of use | |

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument prepaid to the specified center or factory. If requested, an estimate of charges will be made before work begins.

- (1) West Coast Service Center, 3211 S. LaCienega Blvd., Los Angeles, California 90016, Telephone (213) 870-2761, TWX 910-340-6352 for all Singer Instrumentation equipment; or Palo Alto Operation, 3176 Porter Drive, Palo Alto, California 94304, Telephone (415) 493-3231 TWX 910-373-1765 for Palo Alto Operation instruments.
- (2) Include data on symptoms, measurements taken, test instruments used, suspected location of trouble, maintenance action taken, and any other relevant data.

ADDENDUM

for

MODELS RF-100 & RF-100A

I. PURPOSE.

To correct error in parts list.

II. ADDENDUM.

a. In table 6-1, add the following number and name.

74868

Amphenol Corp.

Amphenol Rf Division

Danbury, Conn.

b. In table 6-2, change the "Mfr's Code" of K2 from 74970 to 74868.

ADDENDUM

for

MODELS RF-100 & RF-100A

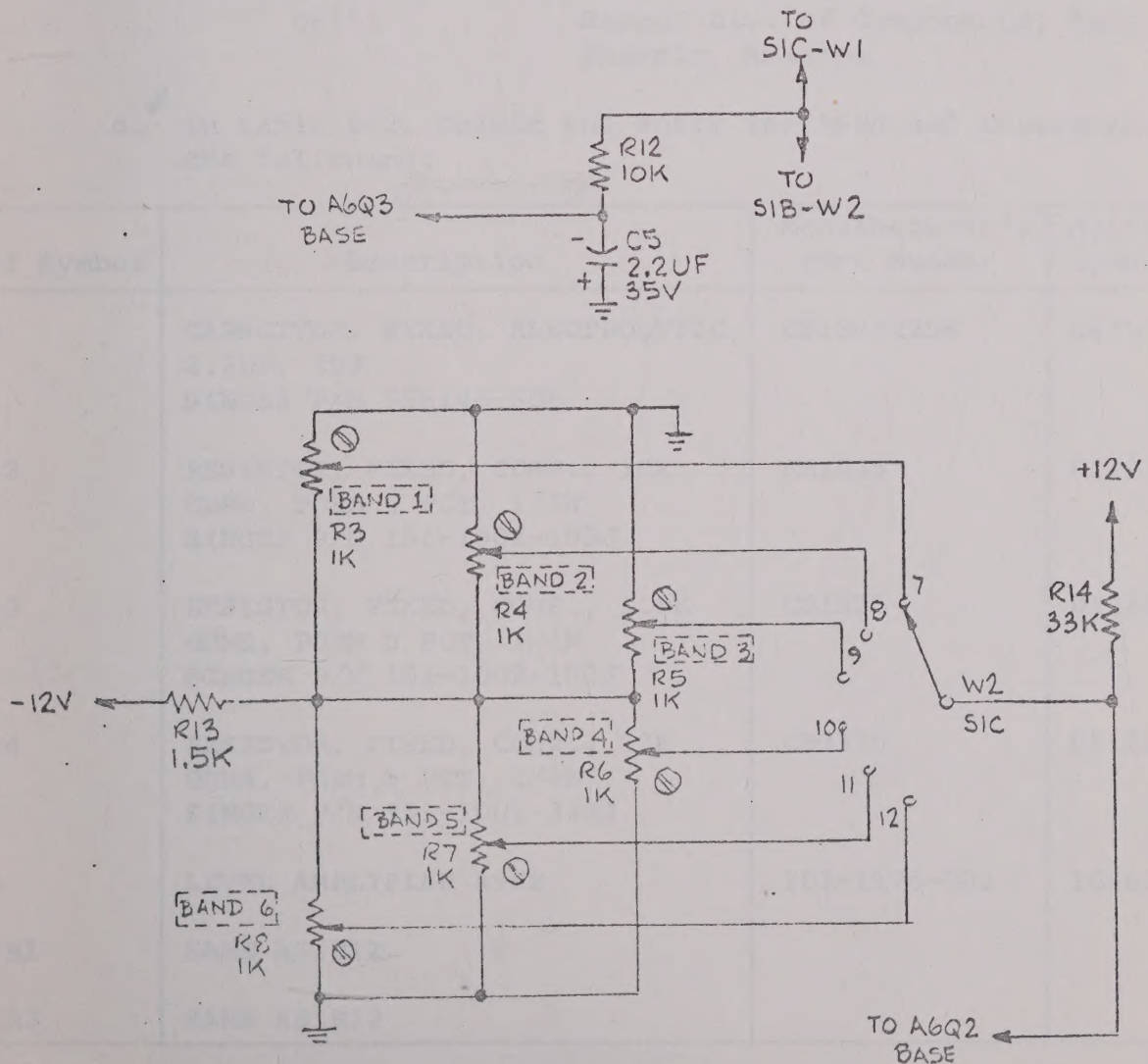
(Effective on equipment serial numbered U30540, U30775 thru U30778, U30780 thru U30783 and U30785 and up.)

I. PURPOSE.

To improve operation of triode oscillator.

II. ADDENDUM.

- a. In figure 5-3, delete resistor A6R4 (10K) and its -12V supply and incorporate the changes shown below:



1. Introduction

The purpose of this report is to provide a detailed analysis of the data collected during the experiment. The results are presented in the following sections.

2. Methodology

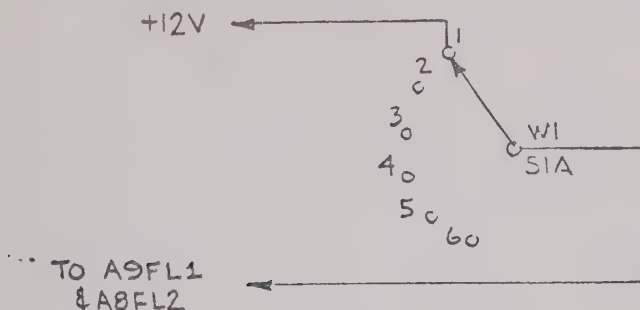
The experiment was conducted using a standard procedure. The data was collected over a period of 10 days.

3. Results

The results of the experiment are shown in the following table. The data indicates a significant increase in the rate of change over time.



- b. ✓ In figure 5-1, delete resistor A6R4 (10K) and its -12V supply, incorporate the two changes shown above and then incorporate the additional change shown below:



- c. ✓ In table 6-1, add:

06751

Semcor Div. of Components, Inc.
Phoenix, Arizona

- d. ✓ In table 6-2, delete the entry for A6R4 and incorporate the following:

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
C5	CAPACITOR, FIXED, ELECTROLYTIC, 2.2UF, 35V SINGER P/N 556146-506	CS13BF225K	06751	1
R12	RESISTOR, FIXED, COMP., 10K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-103J	CB1035	01121	1
R13	RESISTOR, FIXED, COMP., 1.5K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-152J	CB1525	01121	1
R14	RESISTOR, FIXED, COMP., 33K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-333J	CB3335	01121	1
A6	LEVEL AMPLIFIER ASSY	103-1576-002	16665	1
A2R1	SAME AS R12			
A5R3	SAME AS R12			

ADDENDUM

for

MODEL RF-100

Incorporate the following changes into the instruction manual.

- 1.✓ In figure 5-1, delete the value "3.3K" from A8R5.
- 2.✓ In table 6-2, change the entry for A8R5 as indicated below.

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A8R5	RESISTOR, TEMPERATURE SENSITIVE	TM1/4 SERIES	01295	1

Addendum No. 606

MODEL SPA-100 AND MODEL SPA-100A PANORAMIC® MICROWAVE SPECTRUM ANALYZER

Preface to Instruction Manual

GENERAL.

The two technical manuals contained in this handbook cover all of the equipment necessary to form either a PANORAMIC Model SPA-100 Microwave Spectrum Analyzer, which consists of a Model MF-100 Main Frame and a Model RF-100 Tuning Head; or a PANORAMIC Model SPA-100A Microwave Spectrum Analyzer, which consists of a Model MF-100 Main Frame and a Model RF-100A Tuning Head.

DESCRIPTION.

The PANORAMIC Models SPA-100 and SPA-100A Microwave Spectrum Analyzers are extremely versatile universal broadband instruments with highly accurate calibration capabilities. The Model SPA-100 covers the frequency range from 10 MHz to 40 GHz in six bands while the Model SPA-100A covers the range from 0.94 to 40 GHz in five bands. The only difference between the two units is that the former includes a unique up-converter which translates the 10-MHz to 1-GHz input frequency range to the 2.5 to 3.5 GHz band, thereby permitting full 100-MHz dispersion -- even down to 10 MHz.

The modular construction feature of the latest of the SPA-series of spectrum analyzers affords the user extension of the equipment capability to 3-GHz dispersion by the addition of the Model RF-3000 Swept Front End at a later date.

The tuning heads, which are inserted into a front panel opening in the main frame assembly and screwed into place, incorporate the r-f circuitry necessary to convert the applied r-f signal under analysis to the center of the display unit's wideband i-f amplifier passband. Highly efficient first mixers and an extremely stable levelled first local oscillator output provides high sensitivities and gain stability without the need for phase locking. The unique up-converter within the RF-100 enables the full 100-MHz dispersion range to be employed, even when operating at the low end of the analyzer frequency range. Optional external mixers are available for use with both Model RF-100 and RF-100A when operating in the 11-40 GHz ranges.

The Model MF-100 Main Frame contains the circuitry common to the latest of the SPA-series of spectrum analyzers. This solid-state assembly incorporates state-of-the-art wideband and variable bandwidth narrowband i-f amplifiers, a combination wide and narrow swept second local oscillator, a sequential-detection logarithmic i-f amplifier as well as internal marker oscillator, sweep and synchronization circuitry.

Calibrated dispersions of zero (for receiver operation or time-domain analysis) and 10 kHz to 100 MHz, sweep times from 100 microseconds to 10 seconds, resolution bandwidths from 1 kHz to 1 MHz, i-f attenuation from 0 to 69 dB in 1-dB increments as well as calibrated linear, power (square-law) and 60-dB log scale truly make these instruments universal devices. Remote programming capabilities and auxiliary x-y and predetected 60-MHz outputs permit signal analysis from remote locations.

HANDBOOK USE.

Two technical manuals are provided under this cover: the first manual covers both tuning heads, Models RF-100 and RF-100A; and the other covers the Main Frame, Model MF-100. Section I of each manual describes the purpose and use of each unit and also provides, in tabulated form, the unit specifications. Because the tuning head performs the front-end function and determines system operation, those specifications which relate to overall system capabilities are covered in the tuning head manual; while only those specifications covering the presentation are covered in the Main Frame manual.

The procedures for proper operation of the Spectrum Analyzer are dependent upon the associated tuning head. Therefore, the operating procedures are contained in the Operation Section (Section II) of the tuning head manual.

Section III of the Model RF-100 and RF-100A manual covers the theory of operation of both tuning units, for the circuits in each unit are identical, except that Model RF-100 has additional circuitry which is also covered. The Main Frame manual covers all circuitry which follows the generation of the first intermediate frequency, 160 MHz.

Section IV of each manual contains minimum performance standards, component location data, troubleshooting procedures, alignment procedures, and parts removal and replacement procedures. Because of the diversity of tuning head possibilities, procedures for the removal and replacement of the tuning head are provided in the tuning head manual. The procedures covering all other components are covered in the manual housing the components of interest.

Schematic diagrams are provided in Section V of both manuals, and Section VI contains a complete electrical parts list.

WARNING

HIGH VOLTAGE

is used in the operation of this equipment

DEATH ON CONTACT

may result if personnel fail to observe safety precautions

Learn the areas containing high voltage
in each piece of equipment

Be careful not to contact high-voltage connections
when installing or operating this equipment

Before working inside the equipment, turn power
off and ground points of high potential
before touching them

INSTRUCTION MANUAL

Panoramic*

MICROWAVE

SPECTRUM ANALYZERS

MODELS SPA-100 & SPA-100A

THIS HANDBOOK IS TO BE USED
WITH EQUIPMENT SERIAL NUMBERED
U30467 AND UP

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Creative Products for Test, Measurement, Analysis, Calibration

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THE SINGER COMPANY, ELECTRONIC PRODUCTS DIVISION, warrants each instrument sold by it to be free of defects in material and workmanship, effective from the date of shipment to the original purchaser for a period of 1 year except where a specific warranty period is stated in the operating manual.

The Seller will not be liable for incidental or consequential damages. The Seller's sole liability shall be repair, replacement, or return of purchase price at our option. Warranty returns first must be authorized by the factory, and repairs or replacements (at our option) will be made without charge for instruments returned freight prepaid to the factory or authorized repair depot when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, batteries, fuses, lamps, thermoelements and *Ratio Tran* potentiometers are excluded from Warranty coverage. If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, this warranty is VOID.

This warranty is expressly in lieu of any other warranties expressed or implied, including any implied warranty of merchantability, or fitness for a particular purpose, any other obligations or liability on the part of The Singer Company, and it neither assumes nor authorizes any other person to assume for it any other liability in connection with the sale of instruments manufactured by it.

SINGER INSTRUMENTATION

The Singer Company, Electronic Products Division, Home Office: 915 Pembroke Street, Bridgeport, Conn. 06608
Telephone: (203) 366-3201 Twx: 710-453-3483

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- | | |
|--|--|
| 1. Model or Type | 5. Description of trouble ⁽²⁾ |
| 2. Serial Number | 6. Has maintenance action been previously requested? |
| 3. Approximate date instrument was placed in operation | 7. Other comments |
| 4. Approximate number of hours of use | |

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument prepaid to the specified center or factory. If requested, an estimate of charges will be made before work begins.

(1) Contact East Coast Service Center, 915 Pembroke Street, Bridgeport, Connecticut 06608, Telephone (203) 366-3201 or West Coast Service Center, 3211 S. LaCienega Blvd., Los Angeles, California 90016, Telephone (213) 839-2201 for all Singer Instrumentation equipment. If convenient, contact Ballantine Operation, P.O. Box 97, Boonton, New Jersey 07005, Telephone (201) 334-1432 for Ballantine instruments and Alfred Operation, 3176 Porter Drive, Palo Alto, California 94304, Telephone (415) 326-6496 for Alfred instruments.

(2) Include data on symptoms, measurements taken, test instruments used, suspected location of trouble, maintenance action taken, and any other relevant data.

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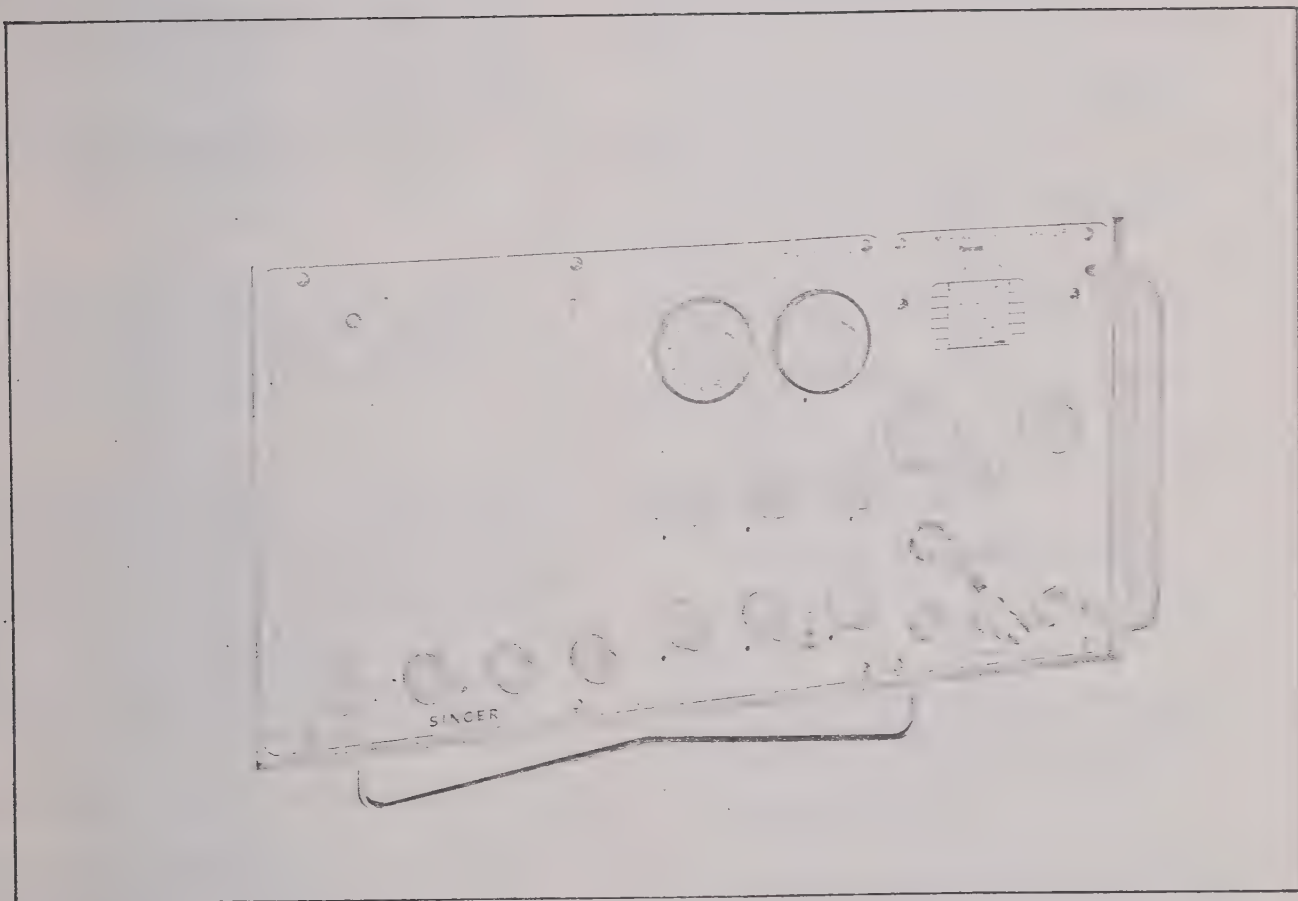


Figure 1-1. Model RF-100 Tuning Head Installed in Model MF-100 Main Frame

SECTION I INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This manual provides general information and operating instructions for the PANORAMIC* Models SPA-100 and SPA-100A (see figure 1-1) Microwave Spectrum Analyzers, manufactured by The Singer Company - Metrics Division. This manual also includes the theory of operation and maintenance data for the front end portion of the analyzers (Model RF-100 Tuning Head for the SPA-100 and Model RF-100A Tuning Head for the SPA-100A).

Note

The general information, theory of operation and maintenance instructions for the Model MF-100 Main Frame portion of the spectrum analyzer is contained in the manual at the back half of this volume.

1-3. The information contained in this handbook reflects the standard Models RF-100 and RF-100A Tuning Heads (hereafter referred to as the RF-100 and RF-100A, respectively) and Models SPA-100 and SPA-100A Microwave Spectrum Analyzers (hereafter referred to as the SPA-100 and SPA-100A, respectively). Differences in equipment configuration, components, specifications and performance resulting from customer application requirements and/or The Singer Company's continuous product improvement program are described in addendum sheets.

1-4. PURPOSE AND USE OF THE EQUIPMENT.

1-5. The RF-100 and RF-100A are multiband tunable front ends which, in conjunction with a Model MF-100 Main Frame (hereafter referred to as the Main Frame) enables the user to visually examine either the amplitude-frequency characteristics or amplitude-time characteristics of applied r-f signals. These instruments are extremely useful for measuring and analyzing various types of r-f signals. Some typical applications of the equipment are listed below:

- a. Dynamic performance analysis of oscillators, generators and transmitters.
- b. Spectrum monitoring of communications channels and radar frequencies.

- c. Analyzing pulsed signals.
- d. Analyzing spectra associated with amplitude-, frequency- and pulse-modulated signals.
- e. Direct reading of power peak and null frequencies.
- f. Microwave equipment malfunction studies (e.g., spurious signals, instabilities, microphonics, etc.).
- g. Factory calibration of production r-f equipment.
- h. Harmonic and other out-of-band measurements.
- i. Examination of cw signal drift, incidental fm and squegging.
- j. Examining dynamic operating characteristics of microwave tubes and devices.
- k. Checking for r-f radiation and leakage.
- l. Determining the presence and frequency of r-f signals.
- m. Use as a sensitive receiver to measure characteristics of microwave components or circuits (e.g., insertion loss and VSWR measurements).
- n. Noise spectra studies.

1-6. Inquiries are invited regarding special applications of the SPA-100 and/or SPA-100A to particular customer requirements. Such inquiries should be directed to the Applications Engineering Department.

1-7. SUPPLIED AND OPTIONALLY AVAILABLE ACCESSORIES.

1-8. Both the SPA-100 and SPA-100A are shipped complete and are ready for use upon receipt. The only supplied accessory is a short patch cable (for use with the SPA-100) which is used to interconnect the SIGNAL INPUT 1-11 GHz and UP CONVERTER OUTPUT jacks of the RF-100 when the SPA-100 is employed in the 10 MHz to 1 GHz band. Optionally available accessories, which are supplied only when

* A Trademark of THE SINGER COMPANY

specifically ordered, are listed and described in table 1-1.

1-9. SPECIFICATIONS.

1-10. The electrical and physical specifications of the SPA-100 and SPA-100A are listed in table 1-2.

1-11. ELECTRON TUBE, TRANSISTOR AND DIODE COMPLEMENT.

1-12. The types and functions of the entire complement of electron tubes, transistors and diodes employed in both the RF-100 and RF-100A are listed in table 1-3.

TABLE 1-1. OPTIONALLY AVAILABLE ACCESSORIES

Nomenclature	Function
Model AT-100 R-f Attenuator Set	A set of three coaxial attenuators (10 dB $\pm$ 1.25 dB, 20 dB $\pm$ 1.5 dB and 30 dB $\pm$ 2 dB) employed to attenuate r-f signals within the 10 MHz to 11 GHz frequency band. These attenuators can be connected in series to provide up to 60-dB of attenuation in 10-dB steps.
Model FL-100 Low-pass Filter	Low-pass filter which, when connected to the RF-100 SIGNAL INPUT 0.01-1 GHz jack during band 1 operation, attenuates the 2.5-GHz local oscillator feedthrough from the jack by 60 db.
Model K _u -100 Waveguide Mixer*	External waveguide mixer (mates with UG-419/U flange) for signals between 11 and 18 GHz.
Model K-100 Waveguide Mixer*	External waveguide mixer (mates with UG-595/U flange) for signals between 18 and 26 GHz.
Model K _a -100 Waveguide Mixer*	External waveguide mixer (mates with UG-599/U flange) for signals between 26 and 40 GHz.
CMF-100 Front Panel Cover	Protective cover for equipment front panel; provides storage space for accessories that are not being used.
Model RM-100 Rack Mounting Ears	Permits mounting of equipment in a standard 19-inch rack.
Model RM-101 Rack Mounting Ears and Slides	Permits slide-mounting of equipment in a standard 19-inch rack.
Connector and Hood (Singer Part Nos. 556146-750 and -758; Continental Connector Corp. Part Nos. SM11-20PGD and -20H-1)	Eleven-pin connector which mates with auxiliary input/output connector J11 on rear panel of Main Frame.
Coaxial Connector (Singer Part No. 556147-019; Sealectro Corp. Part No. 50-11-001)	Coaxial connector which mates with auxiliary 60 MHz OUTPUT connector J11 on rear panel of Main Frame.

* 36-inch coaxial cable furnished with one or more mixer(s) for coupling to RF-100 or RF-100A SIGNAL INPUT 11-40 GHz jack

TABLE 1-2. SPECIFICATIONS

Parameter	Specification
Frequency range	10 MHz to 40 GHz in 6 bands (RF-100) 0.94 to 40 GHz in 5 bands (RF-100A).
Frequency accuracy	$\pm$ 1% of local oscillator frequency

(Cont')

TABLE 1-2. SPECIFICATIONS (Cont'd)

Parameter	Specification		
Sensitivity ¹	Frequency range	L. O. harmonic	Minimum sensitivity
	10 MHz to 1 GHz ²	1st	-90 dBm
	0.94 to 3.5 GHz	1st	-110 dBm
	3.2 to 11 GHz	3rd	-105 dBm
	11 to 18 GHz ³	5th	-90 dBm
	18 to 26 GHz ³	7th	-80 dBm
	26 to 40 GHz ³	11th	-75 dBm
First local oscillator:			
Type	Ceramic triode tunable from 1.1 to 3.7 GHz		
Incidental FM	1 kHz peak-to-peak, maximum		
Dispersion:			
Range	Nine calibrated dispersions from 10 kHz to 100 MHz in 1-3-10 sequence (100-MHz dispersion operative in 10 MHz to 1 GHz band of RF-100); continuously adjustable between steps. Zero dispersion capability for receiver or synchroscope operation.		
Accuracy	±5%		
Phase lock	Stable first local oscillator with low incidental FM provides jitter-free display		
Markers (auto calibration):			
Internal	160-MHz center frequency marker either alone or with selectable 1- and 10-MHz sideband modulation capability		
External	1-kHz to 1-MHz sideband modulation capability of internal 160-MHz center frequency marker		
Signal attenuation:			
R-f	0 to 60 dB in 10-dB steps through the use of optionally available external attenuators (10 MHz to 11 GHz)		
I-f	0 to 69 dB in 1-dB steps; accuracy of ±0.05 dB/dB		
Image separation	320 MHz		
Bandwidths:			
Fixed	Six calibrated steps of 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 1 MHz and AUTO (automatically selects bandwidth for optimum CW resolution)		

Notes: 1 Sensitivity defined as signal plus noise equal to twice noise (S+N=2N) at 1 kHz bandwidth, linear display.

2 SPA-100 only.

3 In conjunction with optionally available waveguide mixers.

(Cont'd)

TABLE 1-2. SPECIFICATIONS (Cont'd)

Parameter	Specification
Bandwidths: (Cont'd)	
Variable	1 to 100 kHz, continuously adjustable
Video filter	Tracked with variable bandwidth, independently adjustable in calibrated bandwidth step positions
Variable i-f gain	20 dB, minimum
Amplitude scales:	
Logarithmic	60 dB (on screen); accuracy ± 2 dB
Linear	Relative voltage; accuracy $\pm 3\%$ of full scale
Power (square law)	Relative power; accuracy $\pm 5\%$ of full scale
CRT	5ADP31M
Graticule	7.5 cm high x 10 cm wide
Sweep modes	Internal, external, manual or single sweep
External sweep input	-5 to +5 volts for full sweep
Sweep time	Eleven calibrated steps from 10 usec/division to 1 second/division in 1-3-10 sequence, continuously adjustable between steps; vernier extends slowest time to at least 3 seconds/division
Spectrum analyzer mode	3 milliseconds/division to 1 second/division
Synchroscope mode	10 usec/division to 1 millisecond/division
Synchronization	Free-running, line, internal or external
External sync level	+3 volts, minimum
Intensifier	Baseline clipper for brighter display of narrow pulses
Auxiliary outputs:	
I-f patch	160 MHz
Vertical output	0 to +1 volt (nominal); source impedance 1000 ohms
Horizontal output	-0.5 to +0.5 volts (nominal); source impedance 1000 ohms
Predetected 60 MHz output	5-MHz bandwidth
Power requirements	115 or 230 vac ($\pm 10\%$), 47 to 440 Hz, 80 watts
Size	16-3/4" wide x 8-23/32" high x 19-1/2" deep
Weight	65 pounds

TABLE 1-3. ELECTRON TUBE, TRANSISTOR AND
CRYSTAL DIODE COMPLEMENT

Reference Symbol Number	Electron Tube, Transistor or Diode Type	Function
Main Chassis		
CR1	1N3011B	Voltage regulator
CR2	132-0220-001 (Singer-Metrics)	Voltage regulator
1-11 GHz Mixer A1		
CR1	1N1132	First mixer
160-MHz Preamplifier A2		
Q1	FT-45 (Fairchild)	160-MHz amplifier
Triode Oscillator A3		
V1	Y1610 (GE-modified)	First local oscillator
160-MHz Preamplifier A5		
Q1	FT-45 (Fairchild)	160-MHz amplifier
Level Amplifier A6		
Q1	2N3440	First local oscillator cathode bias regulator
Q2 and Q3	2N3694	Emitter-coupled difference ampli- fier
0.01-1 GHz Mixer A7*		
CR1	MA417 (Microwave Assoc)	First mixer
Buffer Amplifier/Frequency Multiplier A8*		
CR1	HPA-0112 (HP Assoc)	Frequency multiplier
Q1	2N4427	Buffer amplifier
104.167-MHz Oscillator A9*		
A1Q1	2N3563	104.167-MHz oscillator
A1Q2	2N3642	Buffer amplifier
A2Q1	2N3866	Frequency tripler

* Employed only in RF-100 Tuning Head

SECTION II OPERATION

2-1. GENERAL.

2-2. This section contains instructions for the installation and operation of both the SPA-100 and SPA-100A. It is strongly recommended that the operator become thoroughly familiar with the material in this section before attempting to operate the equipment. Failure to do so may compromise the great versatility that has been engineered into the instrument.

2-3. INSTALLATION.

2-4. The SPA-100 or SPA-100A is shipped complete and is ready for use upon receipt. After the equipment has been unpacked, check the contents of all shipping containers against the packing invoice to ascertain that the order is complete.

2-5. **INSPECTION.** Examine the equipment for indications of damage which may have occurred during shipment. Check all front panel controls for freedom of movement, full travel and positive-detent locking. Note any evidence indicating that the equipment has sustained a severe mechanical shock. Check the condition of all accessories furnished as part of the order. Ascertain that the supplied i-f patch cable is connected between the rear panel IF OUTPUT and IF INPUT jacks and that interlock plug P9 is properly mated to rear panel AUXILIARY MODULE connector J2.

2-6. **BENCH MOUNTING.** The SPA-100 or SPA-100A should be mounted on a sturdy, vibration-free surface. Carefully slide the equipment so that its front panel is parallel to, and a few inches from, the edge of the bench.

2-7. **RACK MOUNTING.** To install the equipment in a standard 19-inch rack, proceed as directed below.

CAUTION

Before installing the equipment into the rack, ascertain that the 115V/230V line switch located on the rear panel of the Main Frame is properly set. Refer to paragraph 2-11.

a. Secure the rack mounting ears to the sides of the equipment (see figure 2-1). For conventional rack mounting, provide an angle bracket at the rear of the rack to support the weight at the rear of the equipment.

b. If the equipment is to be slide mounted, secure the slides to both the sides of the equipment (see figure 2-1) as well as the rack walls.

c. Install the equipment into the rack and secure the rack mounting ears to the Main Frame. Note that there should be a free flow of air around the equipment.

2-8. OPERATING CONTROLS, INDICATORS AND CONNECTORS.

2-9. All controls, indicators and connectors necessary for the operation of the SPA-100 and SPA-100A are located on the equipment front and rear panels as illustrated in figure 2-2; their functions are described in table 2-1.

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS

Control, Indicator or Connector	Figure 2-2 Index Number	Function
MARKER LEVEL control	1	Permits the operator to adjust the level of the selected marker display on the CRT. The marker may be unmodulated, modulated by internal circuitry to provide either 1- or 10-MHz sidebands or modulated by an external source. When the control is rotated fully ccw to OFF, the marker generation circuitry is disabled.
MARKER MODULATION switch	2	Permits the operator to select a marker, as follows: EXT - Center frequency marker is modulated by an external signal source to provide sidebands at

(Cont'd)

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
MARKER MODULATION switch (Cont'd)		frequency increments determined by the source output frequency. OFF - Unmodulated internal center frequency marker is displayed on the CRT. 10 MHz - Center frequency marker is modulated by an internal oscillator to provide sidebands at 10-MHz intervals. 1 MHz - Center frequency marker is modulated by an internal oscillator to provide sidebands at 1-MHz intervals.
IF ATTENUATOR switches	3	Permits attenuation (0 to 69 dB in 1-dB steps) of the i-f input to the Main Frame.
AMPLITUDE SCALE switch	4	Enables the operator to select a 60-dB logarithmic display (LOG), linear display (LIN) or a power display (PWR).
IF GAIN control	5	Adjusts Main Frame i-f gain to enable calibration of the display against a reference input signal.
FREQ DISPERSION switch	6	Selects the dispersion of the display presented on the CRT.
FREQ DISPERSION VARIABLE control	7	Vernier control which permits the operator to reduce the dispersion selected by the setting of the FREQ DISPERSION switch, thereby expanding the presentation for closer signal examination. When the control is rotated fully clockwise to CAL, the display dispersion is that indicated by the setting of the FREQ DISPERSION switch.
SIGNAL FREQ POSITION f_0 COARSE control	8	Enables the operator to place the center frequency marker at the f_0 vertical line of the graticule. This control is effective for all settings of the FREQ DISPERSION switch.
SIGNAL FREQ POSITION f_0 FINE control	9	Vernier adjustment which, in conjunction with the SIGNAL FREQ POSITION f_0 COARSE control, enables the operator to place the center frequency marker at the f_0 vertical line of the graticule. This control is effective for all settings of the FREQ DISPERSION switch except the 10 MHz/DIV, 3 MHz/DIV and 1 MHz/DIV positions.
SIGNAL FREQUENCY GHz dial	10	Indicates the center frequency of the "window" to which the spectrum analyzer is tuned. The index pointer indicates the proper frequency scale to be read.
SIGNAL FREQUENCY TUNING control	11	Tunes the spectrum analyzer to the desired signal input frequency.

(Cont'd)

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
SIGNAL FREQUENCY RANGE switch	12	Permits the operator to select the tuning band compatible with the frequency of the applied signal under analysis. The frequency range of these bands are listed below 0.01 to 1 GHz* 0.94 to 3.5 GHz 3.2 to 11 GHz 11 to 18 GHz 18 to 26 GHz 26 to 40 GHz
UP CONVERTER OUTPUT jack*	13	Provides the up-converted output of low frequency (10 MHz to 1 GHz) signals for application to the SIGNAL INPUT 1-11 GHz jack. The frequency range of these up-converted signals is between 2.51 and 3.5 GHz.
SIGNAL INPUT 11-40 GHz jack	14	Connector which simultaneously couples the local oscillator output to, and the first i-f output from, external waveguide mixers.
SIGNAL INPUT 1-11 GHz jack	15	Connector which accepts applied signals within the frequency range from 1 to 11 GHz. When the SPA-100 is operated in the .01-1 GHz band, this connector accepts the up-converted signal from the UP CONVERTER OUTPUT jack.
SIGNAL INPUT .01-1 GHz jack *	16	Connector which accepts applied signals within the frequency range from 10 MHz to 1 GHz.
SWEEP/SYNC switch	17	Permits the operator to select the desired sweep mode as detailed below. SINGLE (black) sweep - Single sweep is initiated by the momentary depression of the SINGLE pushbutton switch. MAN (black) sweep - Sweep position determined by the MANUAL control. EXT (black) sweep - Sweep determined by an externally generated signal applied to rear panel connector J1-E. INT (black) sweep - Sweep is free-running. EXT (red) sync - Sweep is triggered by an externally generated signal applied to rear panel connector J1-D. INT (red) sync - Sweep is triggered by detected video signal. LINE USE (black) - Sweep is synchronized to power line frequency. LINE CAL (black) - Employed when calibrating the video circuitry during maintenance operations and to indicate the sweep time when the SWEEP VARIABLE control is not set fully clockwise to CAL.

* SPA-100 only

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Figure 2-2 Index Number	Function
MANUAL control	18	Permits manual scanning of the displayed spectrum. This control is operative only when the SWEEP/SYNC switch is set to MAN.
SINGLE pushbutton switch	19	Initiates a single sweep when momentarily depressed. This switch is operative only when the SWEEP/SYNC switch is set to SINGLE.
SWEEP switch	20	Permits the operator to select any one of eleven calibrated sweep times (from 10 microseconds per division to 1 second per division in a 1-3-10 sequence).
SWEEP VARIABLE control	21	Permits vernier increasing of the selected sweep time up to at least 30 seconds.
BANDWIDTH switch	22	Enables the operator to select any one of six calibrated i-f bandwidths (1 kHz to 1 MHz), a continuously adjustable i-f bandwidth from 1 to 100 kHz (VAR) and an automatically selected i-f bandwidth (AUTO) for proper resolution of displayed signals.
BANDWIDTH VARIABLE control	23	Provides continuous uncalibrated adjustment of the i-f and video bandwidth between 1 and 100 kHz when the BANDWIDTH switch is set to VAR; provides independent video filtering for BANDWIDTH switch settings of 1, 3, 10, 30 and 100 kHz and AUTO.
INTENSIFIER control	24	Allows intensification of displayed video pulses while blanking baseline and low-level noise.
H SIZE screwdriver control	25	Adjusts length of CRT trace.
BRIGHTNESS control	26	Adjusts the intensity of the CRT display.
H POS screwdriver control	27	Adjusts the horizontal positioning of the trace.
FOCUS control	28	Permits focusing of the CRT display.
V POS screwdriver control	29	Adjusts the vertical positioning of the trace.
SCALE ILLUMINATION control and switch	30	Control adjusts CRT graticule illumination. When control is set fully counterclockwise to PWR OFF, equipment is de-energized.
CRT display	31	Cathode ray tube display with a calibrated graticule scale having 10 horizontal and seven vertical divisions.
60 MHz OUTPUT jack	Rear Panel	Connector which couples predetected 60-MHz i-f signal to auxiliary test equipment.
IF OUTPUT and IF INPUT jacks	Rear Panel	Connectors which couple the 160-MHz output of the installed tuning head to the i-f circuitry within the Main Frame via a short patch cable.
AUXILIARY MODULE connector J2 and shorting plug P9	Rear Panel	Provides the necessary interlocks for connection to accessory modules such as the RF-3000.

(Cont'd)

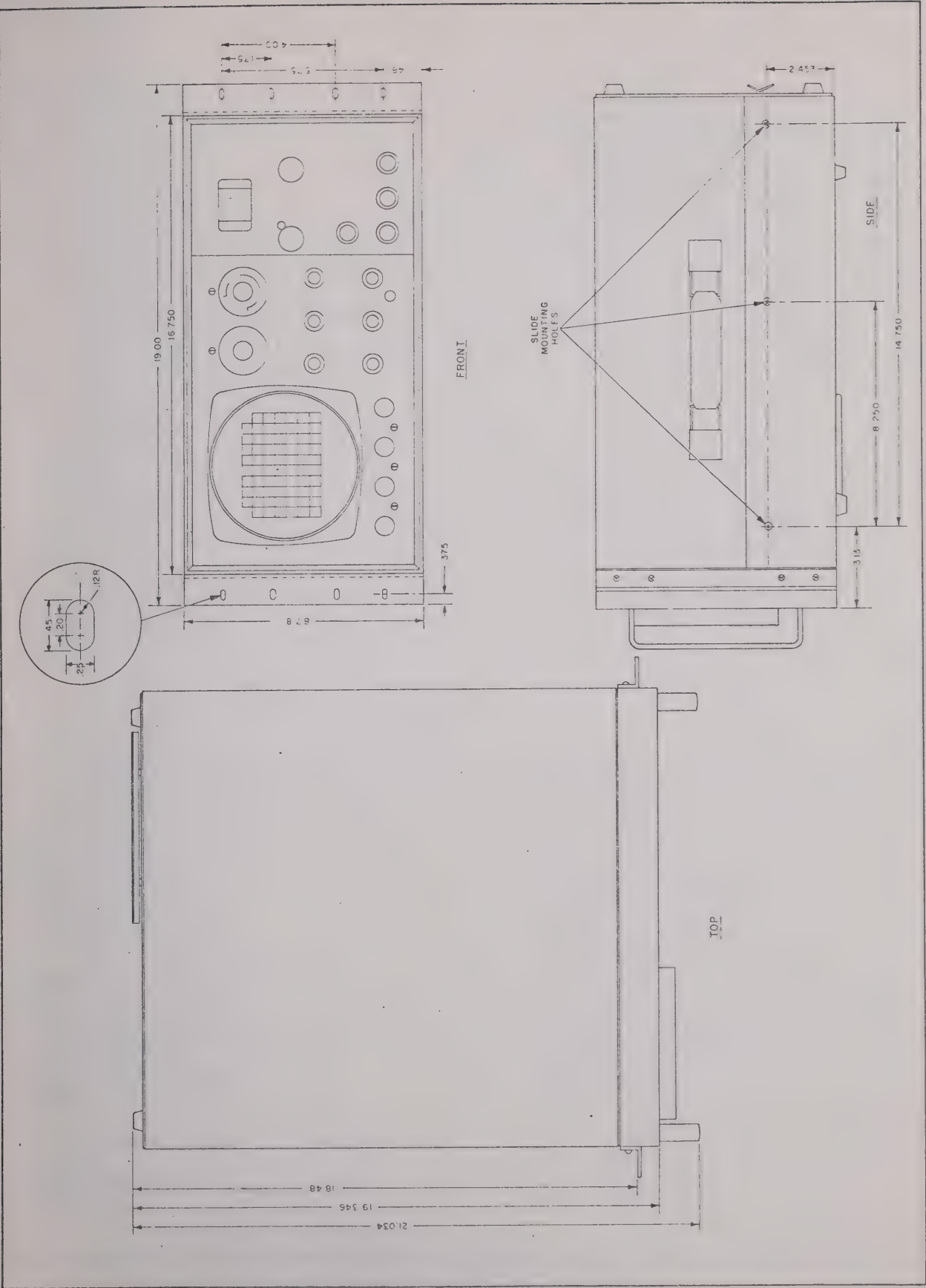


Figure 2-1. Installation Outline Drawing

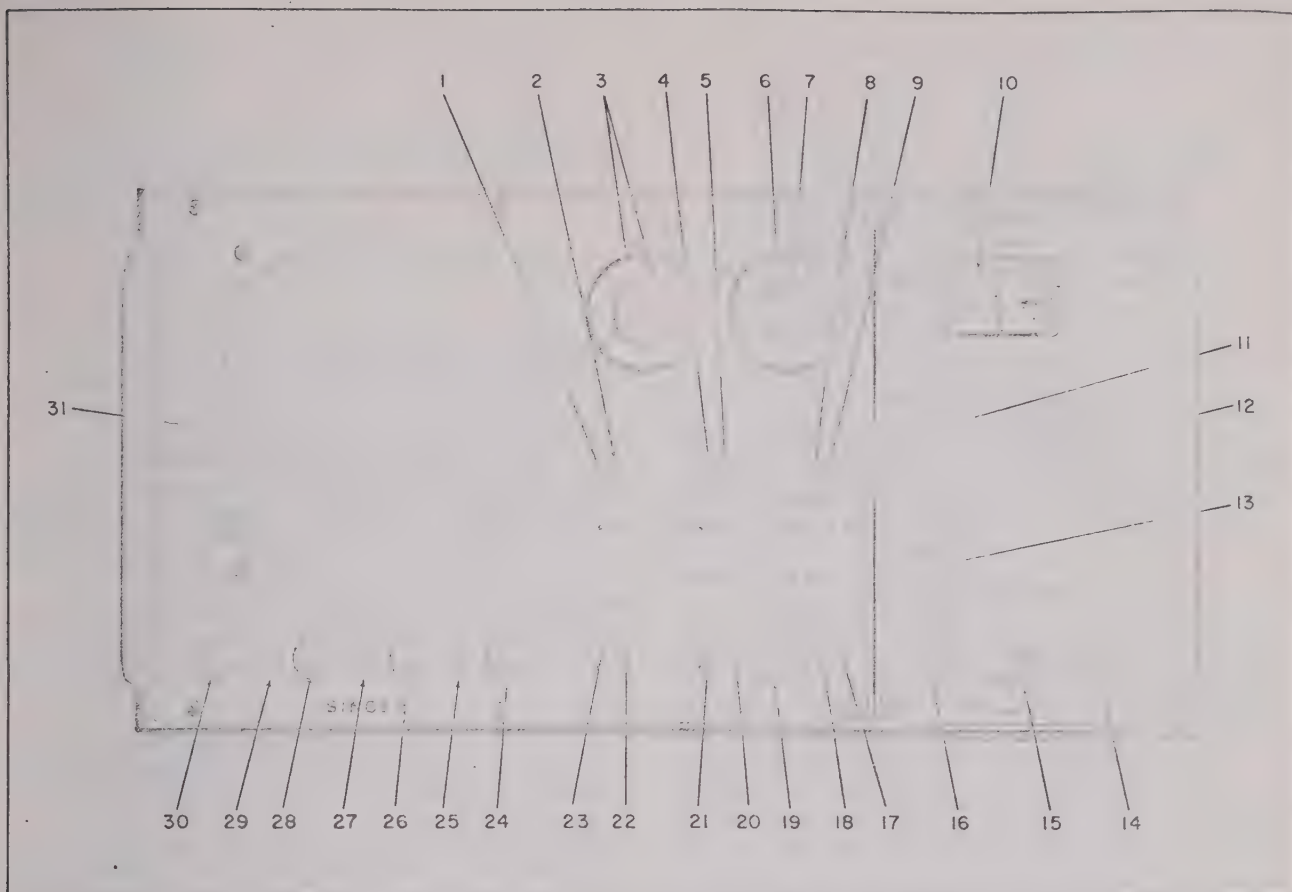


Figure 2-2. Operating Controls, Indicators and Connectors

TABLE 2-2. INITIAL CONTROL SETTINGS FOR PRELIMINARY ADJUSTMENT PROCEDURES

Control	Setting	Control	Setting
FOCUS control	Mid-range	IF GAIN control	Fully ccw
BRIGHTNESS control	Fully cw	SIGNAL FREQ POSITION f_o COURSE control	Mid-range
INTENSIFIER control	Fully ccw	SIGNAL FREQ POSITION f_o FINE control	Mid-range
IF ATTENUATOR switches	00 dB	BANDWIDTH switch	10 kHz
FREQ DISPERSION switch	1 MHz/DIV	BANDWIDTH VARIABLE control	Fully cw
FREQ DISPERSION VARIABLE control	Fully cw (CAL)	SWEEP switch	3 MS/DIV
MARKER MODULATION switch	OFF	SWEEP VARIABLE control	Fully cw (CAL)
MARKER LEVEL control	Fully ccw (OFF)	SWEEP/SYNC switch	INT (black)
AMPLITUDE SCALE switch	LOG	MANUAL control	Any

Section II Operation

c. Adjust the FOCUS and BRIGHTNESS controls to obtain a sharply focused and clearly visible trace.

d. Rotate the IF GAIN control fully clockwise and alternately adjust the H SIZE and H POS screwdriver controls to obtain a display that is centered on the graticule and overlaps the extreme vertical graticule lines by one-quarter division.

e. Rotate the IF GAIN control fully counterclockwise.

f. Adjust the V POS screwdriver control so that the trace coincides with the lowest horizontal graticule line.

g. Set the MARKER LEVEL control fully clockwise and adjust the SIGNAL FREQ POSITION f_0 COARSE control to position the internally generated 160-MHz center frequency marker at the graticule f_0 vertical line.

h. Set the FREQ DISPERSION switch to .3MHz/DIV and adjust the SIGNAL FREQ POSITION f_0 FINE control to position the marker at the graticule f_0 vertical line.

i. Set the FREQ DISPERSION switch to 10 MHz/DIV, the BANDWIDTH switch to 100 kHz and adjust the IF GAIN control for a noise display one division high.

j. Rotate the MARKER LEVEL control fully counterclockwise to OFF. The equipment is now ready for operation.

2-13. GENERAL OPERATING PROCEDURES.

2-14. To scan the frequency spectrum of any band, proceed as directed in the following steps.

a. After power has been applied and the equipment has been adjusted as detailed in paragraphs 2-11 and 2-12, set the SIGNAL FREQUENCY RANGE switch to the desired band to be scanned. Note that the red index on the SIGNAL FREQUENCY GHz dial indicates the selected band.

b. Rotate the SIGNAL FREQUENCY TUNING control to obtain a SIGNAL FREQUENCY dial indication corresponding to the low end of the selected band.

c. Couple the signal under analysis to the appropriate input jack.

2. The signal input level should not exceed -30 dBm. Signal amplitudes above this level will result in distortion and the generation of spurious signals.

3. If the input signal frequency is within the frequency range from 11 to 40 GHz, couple the signal to the appropriate external waveguide mixer (Model K_u-100, Model K-100 or Model K_a-100, as required) and couple the coaxial connector of the mixer to the SIGNAL INPUT 11-40 GHz jack.

d. Rotate the SIGNAL FREQUENCY TUNING control clockwise in search of the applied signal; the signal should enter the display from the right as the SIGNAL FREQUENCY TUNING control is rotated clockwise. If the signal enters the display from the left, it is an image signal. Once the desired signal is within the calibrated display, adjust the SIGNAL FREQUENCY TUNING control to center the presentation.

e. To determine the frequency of a spectral component, turn on the 160-MHz marker and determine the number of divisions the particular component is from the marker line (when the FREQ DISPERSION VARIABLE control is set fully clockwise at CAL). Since the marker represents the frequency which the SIGNAL FREQUENCY dial is indicating, the frequency of the particular spectral component is equal to the SIGNAL FREQUENCY dial indication plus (if the signal is to the right of the graticule f_0 vertical line) or minus (if the signal is to the left) the product of the selected frequency dispersion and the horizontal displacement from the marker. For example, if the SIGNAL FREQUENCY dial indicates 10.60 GHz, the FREQ DISPERSION switch is set at 10 MHz/DIV and the spectral component is 2-1/2 divisions to the left of the marker, the frequency of the component would be $10,600 - 25 = 10,575$ MHz. Another method of determining the frequency would be to energize the internal 10- or 1-MHz markers and counting the number of markers between the 160-MHz marker and signal component.

2-15. OBTAINING PROPER RESOLUTION. At wide bandwidths, input signals having a small frequency difference tend to merge into and mask each other. The ability of the analyzer to separate and identify individual signals depends upon two factors: the scanning velocity (the selected frequency dispersion in MHz/DIV or kHz/DIV divided by the selected sweep time in MS/DIV and the bandwidth of the i-f amplifier stages (see figure 2-3). For any given scanning velocity, there is a corresponding i-f bandwidth for optimum resolution: the relationship being

$$R \approx 1.5\sqrt{\frac{D}{T}}$$

where R is the bandwidth for optimum resolution (in Hz).

D is the selected dispersion (in Hz) and

T is the selected sweep time (in seconds)

Notes

1. If the SPA-100 is to analyze input signals within the frequency range from 10 MHz to 1 GHz, couple the signal to the SIGNAL INPUT .01-1 GHz jack and, using the supplied jumper cable, couple the SIGNAL INPUT 1-11 GHz jack to the UP CONVERTER OUTPUT jack.

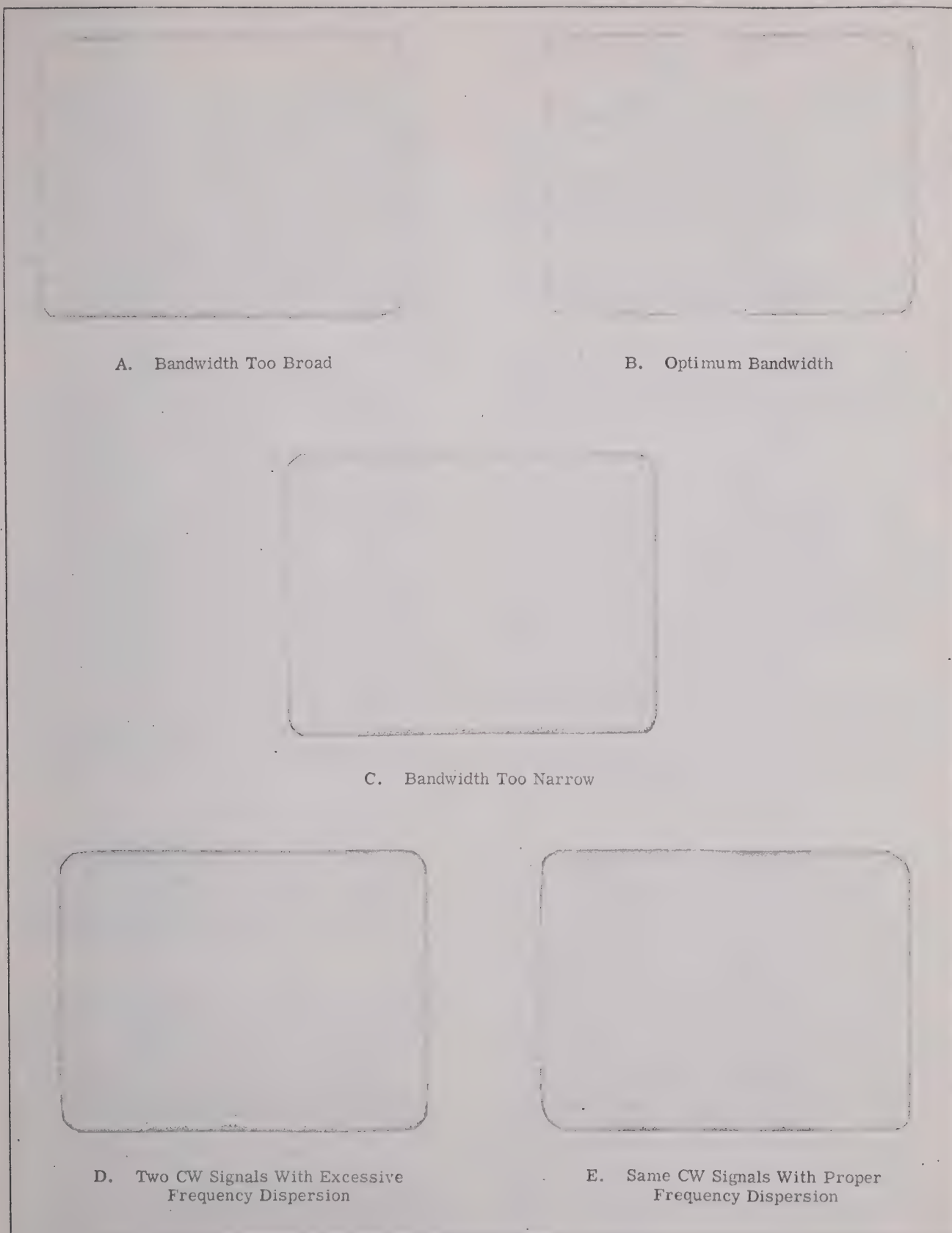


Figure 2-3. Effects of Operating Controls on Display

The BANDWIDTH switch should be set to a value equal to or slightly greater than R for optimum resolution.

The scanning velocity can be reduced by decreasing the frequency dispersion scanned by each sweep or by increasing the time for one sweep. Reduction of the i-f bandwidth improves the resolution (the ability of the analyzer to separate closely-spaced signal components). If the frequency of a low amplitude signal is close to the frequency of a larger amplitude signal, the smaller pip will be masked by the skirt of the larger pip (the amplitude-versus-frequency response of the i-f circuitry being bell-shaped). As the frequency separation between the two signals increases, or the resolution of the analyzer increases, the individual signal characteristic error becomes less.

2-16. When the CRT displays a group of closely-spaced signals (such as a carrier and its sidebands) with the analyzer set for wide dispersions, the display may appear as a single pip. To examine this group of signals more closely, the operator should first center that portion of the display to be analyzed in greater detail about the graticule f_0 vertical line by adjustment of the SIGNAL FREQUENCY TUNING control and then set the FREQ DISPERSION switch for a reduced dispersion. Further improvement in display resolution may be achieved by setting the BANDWIDTH switch to VAR and adjusting the BANDWIDTH VARIABLE control until the best resolution is obtained: The BANDWIDTH VARIABLE control permits continuous adjustment of the i-f bandwidth from 1 kHz to 100 kHz. Narrowing of the i-f bandwidth (for a given scanning velocity) improves display resolution. Further reduction of the i-f bandwidth beyond the point of optimum resolution causes a severe reduction in amplitude display for CW or narrowband signals due to the limited response of the i-f amplifiers.

Note

When the BANDWIDTH switch is set to AUTO and the SWEEP switch is set to 10 MS/DIV, the proper i-f bandwidth for optimum resolution of CW or narrowband signals is automatically selected by the setting of the FREQ DISPERSION switch.

2-17. Another way to obtain better resolution is to increase the sweep time (i.e., rotate the SWEEP switch counterclockwise). The selection of the appropriate sweep time is determined by the nature of the signal being studied. For example, when the applied signal under analysis is sporadic, it is desirable to operate at short sweep times to increase the probability of intercepting the signal. When examining pulse spectra, reducing the sweep time will reduce the number of pulse lines per scan if the PRF of the applied pulse is less than the i-f bandwidth of the analyzer. However, when the PRF of the applied signal is greater than the i-f bandwidth of the analyzer, the number of lines is constant regardless of the sweep time (spectral line case).

2-18. To increase the resolution capability by reduction of the frequency dispersion, narrowing the i-f bandwidth and increasing the sweep time, the following procedure should be used.

- a. Set the BANDWIDTH switch to VAR and rotate the BANDWIDTH VARIABLE control fully clockwise (i-f bandwidth = 100 kHz).
- b. Adjust the SIGNAL FREQUENCY TUNING and/or SIGNAL FREQ POSITION f_0 COARSE and/or FINE controls so that the desired band of signals appears centered on the screen.
- c. Rotate the FREQ DISPERSION switch counterclockwise to spread the band of signals across the screen.
- d. Rotate the BANDWIDTH VARIABLE control counterclockwise until the individual signal components are clearly resolved. If proper (optimum) resolution cannot be achieved, repeat step c, set the SWEEP switch to the next slower sweep time and repeat step d.

2-19. When analyzing pulsed r-f signals it is often more desirable to view the envelope of the pulse spectrum rather than the individual spectral lines. If individual spectral lines are displayed, increase the i-f bandwidth by rotating the BANDWIDTH switch clockwise until only the envelope is displayed. To examine the envelope of noise, set the BANDWIDTH switch to 100 kHz and rotate the BANDWIDTH VARIABLE (video filter) control counterclockwise until only the noise envelope is displayed.

2-20. ZERO FREQUENCY PIP. When the SPA-100 is tuned near the low end of the 10 MHz to 1 GHz band when using dispersions in excess of 10 MHz, a zero frequency pip will appear on the display. That portion of the display to the left of zero pip is not calibrated and no information should be inferred from the appearance of the display to the left of the zero pip.

2-21. PROPER USE OF CRT SCALES. The proper use of the LOG, LIN and PWR scales is detailed in paragraphs 2-22 through 2-24, respectively.

2-22. LOG Scale. Proper use of the 60-dB LOG scale requires that the dynamic range be equal to or greater than 60 dB. The dynamic range is limited at the low end by equipment sensitivity and at the high end by over-driving of the first mixer (typically at input levels in excess of -15 dBm). To obtain the greatest upper limit capability, there must be a minimum of losses in the i-f chain: the IF ATTENUATOR switches must be set to 00 DB. The lower limit, sensitivity, is determined by the setting of the BANDWIDTH switch and the IF GAIN control. Since the sensitivity is related to the i-f bandwidth, it is recommended that the optimum bandwidth be employed (refer to paragraph 2-15) and the IF GAIN control be adjusted to obtain a noise display one division high. Note that, although a 60-dB dynamic range is achieved, spurious responses may be generated (refer to paragraphs 2-36 through 2-38).

2-23. **LIN Scale.** The LIN scale should be employed when it is desired to measure the amplitude difference between signals within 20 dB of each other. Note that when switching between LOG, LIN and PWR scales, the position of the trace baseline may shift vertically; the V POS screwdriver control should be adjusted to return the baseline to the lowest horizontal graticule line after scale switching has been accomplished. Should the display amplitude exceed the calibrated region of the graticule, employ the IF ATTENUATOR switches to return the display to within the calibrated area.

2-24. **PWR Scale.** The PWR scale is employed whenever the amplitude difference between two displayed signals is small. The PWR scale, which is square-law in nature, exaggerates small amplitude differences. As in the case with the LIN scale, the shift in baseline position should be corrected by adjustment of the V POS screwdriver control and the IF ATTENUATOR switches should be set to maintain a display within the calibrated area of the graticule.

2-25. **INPUT SIGNAL CLASSIFICATION.** In general, signals applied to the spectrum analyzer may be divided into two types; discrete and non-discrete. Discrete signals are in the form of periodic waveforms having frequency components which do not vary appreciably with time. The internally generated markers are typical of such signals. Although the marker output consists of harmonically related components, each frequency is discernible as a separate marker pip on the display, provided that the resolution is proper for the frequency spacing of the markers. In practice, discrete signals are typical of periodic oscillation such as modulated or unmodulated signal generators or oscillator outputs.

2-26. Non-discrete signals are typified by random noise, and the frequency distribution of energy is spread out over a broad band of the spectrum rather than consisting of line spectra. Non-discrete signals are displayed on the spectrum analyzer as a varying envelope of amplitude at each spectrum sample. The three amplitude scales (LOG, LIN and PWR) are equally valid for both random and discrete signals. It should be noted that discrete signal levels should be compared only to other discrete signal levels when relative signal strengths are to be determined and random signal levels compared to other random signal levels.

2-27. **INTERPRETATION OF SCREEN PRESENTATIONS.** With a little experience in the operation of a spectrum analyzer, the user will be able to readily recognize the character of the type of signal being displayed.

a. A cw signal (see figure 2-4a) appears as a deflection of fixed amplitude with the width of the presentation depending on the selected frequency dispersion, i-f bandwidth and sweep time. If the scanning velocity is not too fast, the display will be the frequency response of the i-f amplifier. Deviations from a true cw signal can be recognized as follows:

(1) Oscillator drift - display moves slowly across the screen.

(2) Periodic drift - display moves back and forth across the screen.

(3) Squegging (interruption of an oscillator at an audio or video rate) - display will resemble that of a pulse modulated signal and sideband components will be present in lobes on either side of the signal.

(4) Incidental fm - carrier pip appears to jitter on the display.

b. Two cw signals which are so close in frequency as to cause aural interference (beats) may appear as a single signal whose amplitude varies at a cyclic rate. Further separation will cause a dip at the apex of the display. By improving the resolution, the two signals will gradually separate and become readily identified. (See figure 2-4b.)

c. An amplitude-modulated carrier appears as a deflection of varying amplitude when the modulating frequency is very low. Non-constant tone modulation of low frequency will produce a series of convolutions varying in amplitude along the sides of the carrier pip. As the modulation frequency increases, convolutions move away from the deflection and sidebands become visible. (See figure 2-4c.) It becomes possible to identify the sidebands by reducing the dispersion and increasing the resolution.

d. The appearance of single-sideband signals depends on the type of modulation employed. Tone-modulated single-sideband signals appear as a carrier (for a single tone) or a series of carriers (for multi-tones) of slightly different frequency. Voice or music modulated single-sideband signals appear as a smear of rapidly varying signals which occupy a finite bandwidth. Figure 2-4d illustrates an amplitude-modulated single-sideband signal without carrier suppression.

e. Frequency-modulated carriers appear as a series of vertical deflections as illustrated in figure 2-4e. The spectral lines are spaced at multiples of the modulating frequency. A carrier that is frequency-modulated at a low rate appears as a carrier that wobbles sideways. The vertical deflections shift rapidly when the carrier is modulated by voice or music, as illustrated in figure 2-4f.

f. A pulse-modulated signal (see figure 2-4g) will consist of a series of vertical spikes. The number of spikes is dependent on the pulse repetition rate, the i-f bandwidth and the sweep time. The amplitude of each spike represents the energy present at the particular frequency during one of the pulses. The peak envelope of all the spikes represents the energy distribution pattern of the signal.

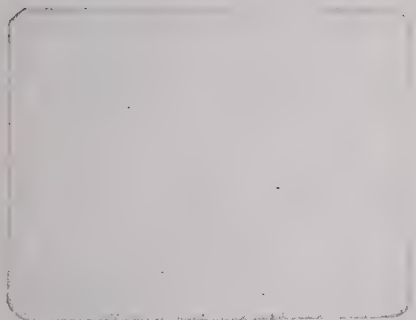
g. An impulse generator produces a train of very narrow pulses at a relatively low prf. The spectrum, which is essentially an exaggerated pulsed r-f



A. CW Signal



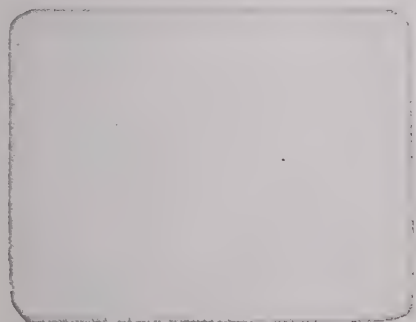
B. Two Interfering Carriers at Optimum Resolution



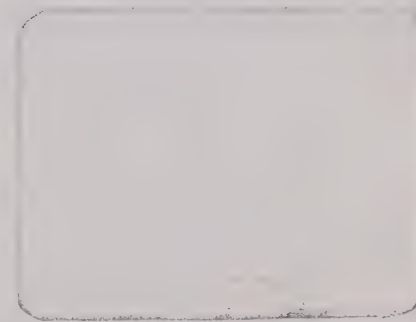
C. Single Tone Amplitude Modulated Signal



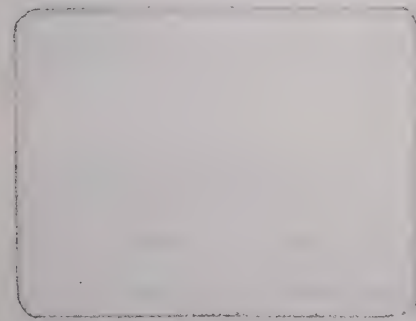
D. Single-sideband Signal Without Suppressed Carrier



E. Frequency Modulated Signal



F. Typical Sideband Energy of Speech Modulated FM Signal (Slow Sweep Used to Display Envelope Averages)



G. Pulsed R-f Signal



H. Impulse Generator Output

Figure 2-4. Typical CRT Presentations of Discrete Signals

display, consists of an extremely broad and quite flat central lobe with very closely spaced spectral lines. (See figure 2-4h.)

h. Radio frequency interference signals of various types may appear on the screen of the spectrum analyzer. Such signals may have either broad or narrow spectral distributions, depending on the type of interference, and may occur at constant or random repetition rates. Signals which occur at a variable repetition rate (such as those produced by accelerating motors, vibrators, buzzers, etc.) may move in either direction along the frequency axis; this is caused by the fact that the spectrum analyzer is sweeping at a fixed rate whereas the observed signal occurs at a variable rate. These pips will be stationary on the screen when there is synchronization between the signal and the sweep. Signals produced by electrical arcing, switching transients, static and other short electrical impulses have broad spectra which may cover the entire frequency range of the spectrum analyzer.

2-28. CHARACTERISTICS OF PULSED R-F DISPLAYS. Since the examination of pulsed r-f signals represents an important application for spectrum analyzers, it is well to consider the characteristics of these signals and their appearance on the analyzer display. The pulse that modulates the r-f carrier contains as its frequency components the pulse repetition frequency and its harmonics. The pulsed r-f signal therefore consists of the carrier frequency and sideband components spaced at the pulse repetition frequency at either side of the carrier. Thus, the greater the pulse repetition frequency, the greater the spacing between adjacent sideband spectral lines. The width of the main lobe is equal to twice the reciprocal of the pulse width ($\frac{2}{\tau}$) while both the width of each of the side lobes and the frequency difference between the carrier and the first null point is equal to the reciprocal of the pulse width ($\frac{1}{\tau}$). Figure 2-5 illustrates typical pulsed r-f displays. Figure 2-5a shows a perfect pulsed r-f signal; the spectrum is characterized by symmetrical upper and lower sidebands and by the null points reaching the baseline. When the carrier has FM during the time of the pulse, the null points no longer reach the baseline (see figures 2-5b and 2-5c). When there is AM during the time of the pulse, the upper and lower sidebands are lower in amplitude and are spread further apart, as illustrated in figure 2-5d. Figures 2-5e and 2-5f show the effect of simultaneous amplitude and frequency modulation on the spectrum of a pulsed r-f signal.

2-29. The actual spectral lines for a repetitive pulse can be observed on an analyzer when the pulse repetition rate is greater than the resolution of the analyzer for the dispersion and sweep rate selected. When spectral lines are to be resolved, a dispersion not exceeding 100 times the prf must be employed to enable adequate visual resolution on a 5-inch CRT. Suitable i-f bandwidths and sweep rate settings less than the prf are also required for resolution of the spectral lines. For typical prf's and pulse widths, the actual spectral lines of a pulse are not resolved.

In practical r-f and microwave pulsed signal analysis, the envelope of the signal is of greatest interest.

2-30. Figure 2-6 depicts the various displays obtainable of a given pulsed signal as a function of spectrum analyzer parameters. Accurate pulse spectrum plotting requires adequate selectivity for precise plotting of lobes and nulls. Excessive i-f bandwidths smear and degrade the lobe display, as illustrated in figure 2-6a. A good empirical compromise between adequate selectivity and excessive loss of pulse sensitivity due to the reduction in bandwidth is an i-f bandwidth of one-tenth the pulse width (see figure 2-6c). In use the operator sets the bandwidth as broad as possible consistent with an adequately sharp null definition for the lobes. The sweep rate is usually set at less than 1% of the prf to display at least 100 pulses per scan for adequate sectional representation. A stationary spike pattern is readily obtained through the use of external sweep synchronization. Pulse irregularities and missing pulses can be checked conveniently in this manner. Inexperienced users of spectrum analyzers often confuse the spikes due to each pulse with actual spectral lines. A simple test to determine whether spectral lines or pulse spikes are being displayed is to observe the effect that variation of the sweep rate has on the display; if the number of vertical deflections remains unchanged, true spectral lines are being displayed (see figure 2-6d).

2-31. An important factor to be considered in the analysis of narrow pulsed signals is the analyzer's usable pulse sensitivity. Spectrum analyzers are normally rated and specified for cw sensitivity at minimum i-f bandwidth. The relationship* between cw and pulse sensitivity is

$$e_{\text{pulse}} = \left(\frac{3}{2} \tau \Delta f_{\text{i-f}} \right) e_{\text{cw}}$$

where

e_{pulse} = sensitivity to a pulsed r-f signal,

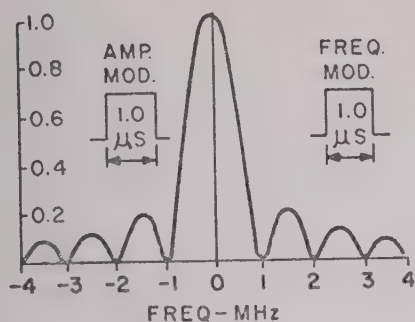
e_{cw} = sensitivity to a cw signal at the same frequency,

τ = pulse width (in seconds), and

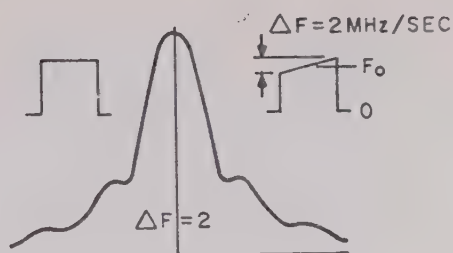
$f_{\text{i-f}}$ = analyzer 3-dB bandwidth (in Hz)

2-32. If for example, a 0.1 microsecond pulse is applied to a spectrum analyzer whose 3-dB bandwidth is 100 kHz, $e_{\text{pulse}} = 1.5 \times (0.1 \times 10^{-6}) \times (100 \times 10^3) e_{\text{cw}} = 0.015 e_{\text{cw}}$, which corresponds to a 36 dB loss in sensitivity. This loss in sensitivity is due to the fact that the i-f bandwidth required for pulse displays ($\approx \frac{0.1}{\tau}$) is much greater than the i-f bandwidth for cw displays, thereby the front end produces a much greater noise background. For a spectrum analyzer with a rated cw sensitivity at 1 kHz

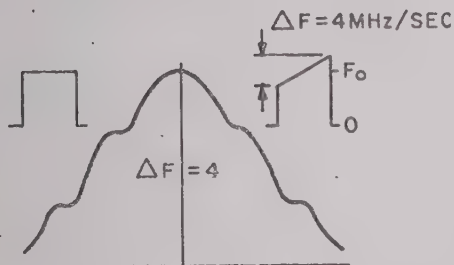
* MIT Radiation Laboratory Series, Volume XI, Chapter 7



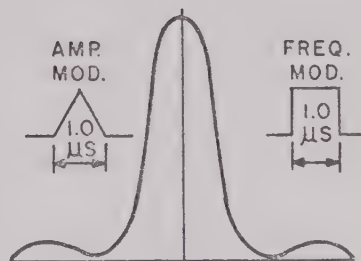
A. Spectrum of a rectangular pulse without AM or FM occurring during pulse. Shape is that of a $\frac{\sin \frac{\omega \tau}{2}}{\frac{\omega \tau}{2}}$ function.



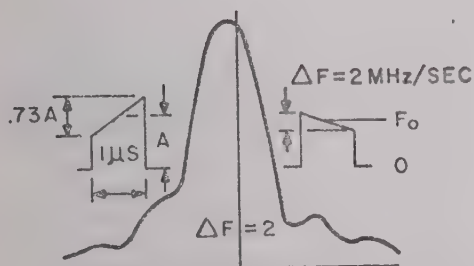
B. Spectrum of a rectangular pulse with linear FM resulting in increased sidelobe amplitude and minimums not reaching zero.



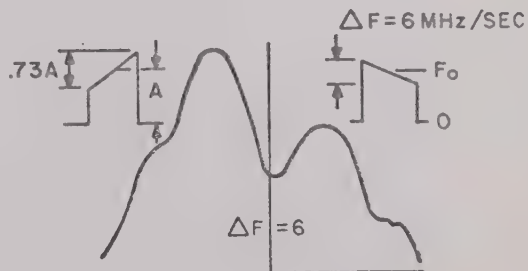
C. Same pulse as B but with more severe FM.



D. Triangular pulse spectrum without FM during pulse. Effective pulse width is shorter than A, causing minimums to occur at wider intervals of frequency and lower sideband amplitudes.



E. Effect of linear AM and FM during pulse. Observe loss in symmetry due to pulse amplitude slope.

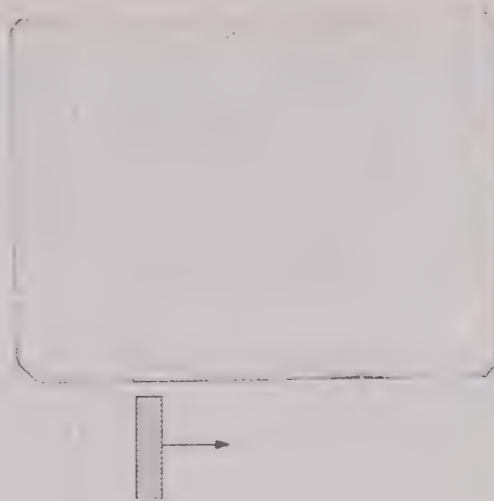


F. More severe case of FM and AM occurring during pulse.

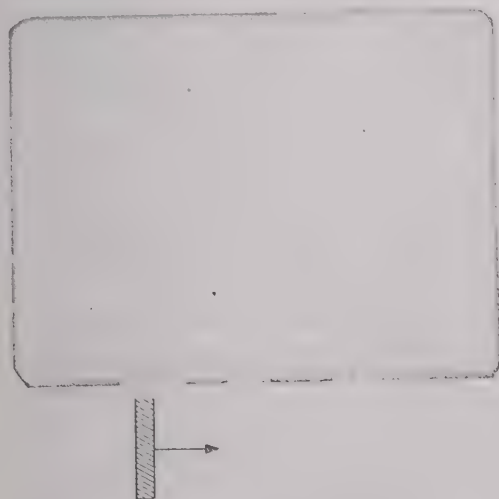
Figure 2-5. Typical Pulsed RF Displays



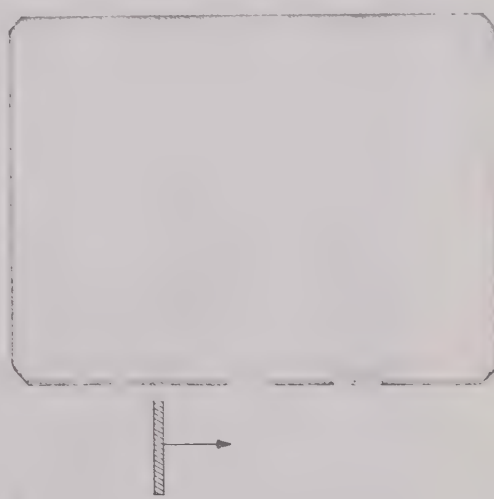
A. Extreme Case ($\Delta f_{if} \approx 1/\tau$): Extremely wide bandwidth yields minimum information.



B. Inaccurate Envelope Case ($\Delta f_{if} \approx 0.5/\tau$): Excessive i-f bandwidth fails to resolve lobe null points and distorts envelope.



C. Accurate Envelope Case ($\Delta f_{if} \approx 0.1/\tau$): Moderately narrow bandwidth does not resolve spectral lines but plots spectrum envelope accurately. Moderate prf.



D. Spectral Line Case ($\Delta f_{if} < f_{prf}$): Very narrow bandwidth resolves spectral lines (within limitations of CRT beam width and visual discrimination). High prf.

Δf_{if} = analyzer i-f bandwidth (Hz)

f_{prf} = input pulse repetition rate (pps)

τ = input pulse duration (seconds)

Figure 2-6. Effect of PRF and Analyzer Bandwidth on Pulsed Signal Analysis

bandwidth, there would be an additional 20 dB of background noise when the bandwidth is set to 100 kHz. Thus, for the example given above the total sensitivity difference between the deflection due to the 0.1 microsecond pulse @ 100 kHz i-f bandwidth and the cw signal sensitivity @ 1 kHz bandwidth would be $36 + 20 = 56$ dB. At a frequency where the cw sensitivity of the spectrum analyzer is -110 dBm and the maximum signal input level for linear operation is -30 dBm, the maximum usable dynamic range for this pulse will be $24 \text{ dB} [-30 \text{ dBm} - (-110 \text{ dB}) - 36 \text{ dB} - 20 \text{ dB}]$. For many applications where the major lobes are of prime interest, the maximum input level can be somewhat greater without significant measurement error. A practical test of adequate freedom from non-linear operation is to check the proportionality of the change in the spectrum display when a small, calibrated amplitude change is introduced. Insertion of 10-dB of attenuation into the input signal path can be used to verify that the analyzer is not being overloaded. The analyzer's sensitivity for pulsed signals can be determined by adding the loss of sensitivity (a positive value) to the cw sensitivity @ 1 kHz bandwidth (see figure 2-7).

2-33. NOISE ANALYSIS. In noise analysis (noise being defined as randomly fluctuating signals), the same general techniques are used for setting the equipment for the spectrum of interest as are used for discrete signals. If the input spectrum is broadband, it is very important to monitor the input signal

level to prevent equipment overload. The following special techniques should be noted.

a. In general, a fairly wide i-f bandwidth is preferred for noise analysis. This permits relatively rapid scans since a wide i-f bandwidth gives better noise envelope averaging than does a narrow i-f bandwidth. However, if the noise source is highly selective, an i-f bandwidth which is narrow compared to the bandwidth of the resonance is required. This permits a detailed presentation of the noise characteristics. When a narrow i-f bandwidth is used, a low sweep rate is necessary for correct amplitude presentation.

b. The proper sweep rate can be determined by changing the sweep time slightly and noting whether or not there is any change in the envelope amplitude. (The portion of the envelope having the greatest slope should be examined since the greatest change will occur there.) The sweep rate should be slow enough so that a small change in the sweep rate does not result in an amplitude change. If the sweep rate is at a minimum, the frequency dispersion should be reduced and/or the i-f bandwidth increased until it is possible to make a small change in sweep rate without changing the amplitude. Once a sweep which is slow enough to obtain correct results has been established, a slower sweep can be set if improved envelope averaging is required.

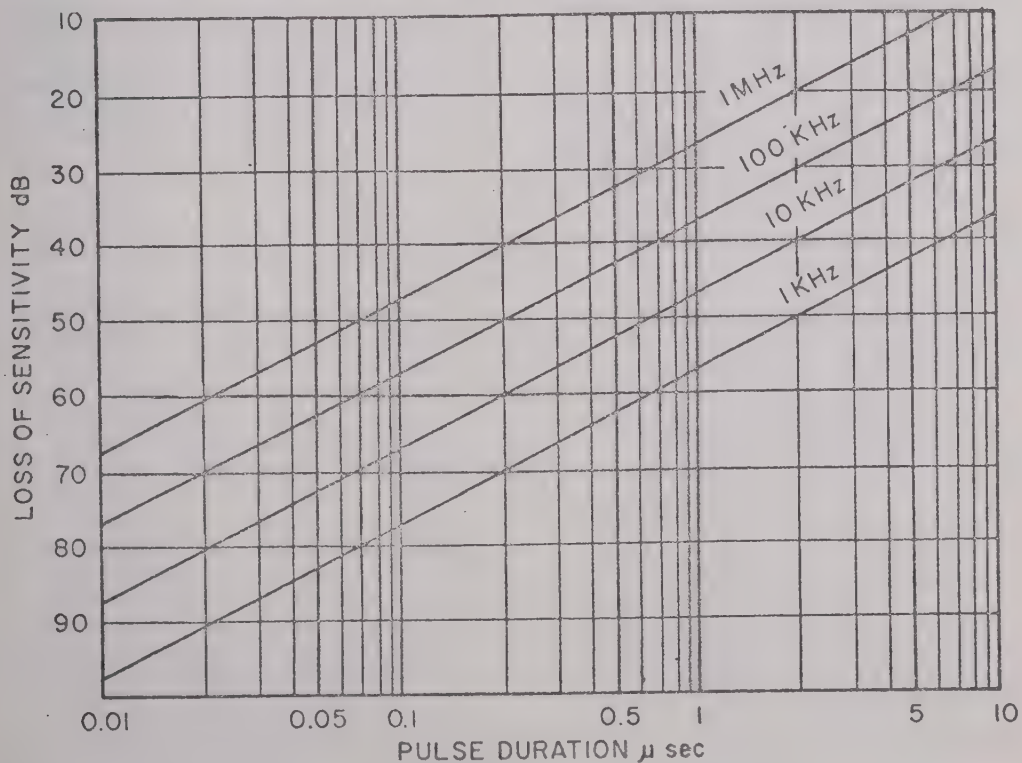


Figure 2-7. Analyzer Sensitivity Correction Due to a Pulsed Signal Compared to a CW Signal at 1 kHz Bandwidth

c. In noise analysis, video filtering can be used to obtain averaging of the noise spectrum envelope. It is usually desirable to rotate the BANDWIDTH VARIABLE control counterclockwise while the BANDWIDTH switch is in the 1, 3, 10, 30 or 100 kHz position until a single-line presentation is obtained.

d. Note that the equipment sensitivity specification in Section I is applicable only for discrete signals. If absolute noise amplitude measurements are required, the spectrum analyzer should be calibrated with a noise source of known noise output level. Such a calibration should be made at the same scanning velocity (dispersion divided by sweep time) and i-f bandwidth that is used for the signal measurement.

2-34. UNDESIRABLE RESPONSES. Because the spectrum analyzer has a broadband input section, undesirable responses may appear on the CRT screen. These responses, and how to recognize them, are described in paragraphs 2-35 through 2-41.

2-35. 160-MHz I-f Feedthrough Response (SPA-100 10-MHz to 1-GHz Band). This signal is easily recognized since the resultant pip will not move across the screen as the SIGNAL FREQUENCY TUNING control is adjusted, and will remain stationary like an injected marker signal. This response will be usually at least 30 dB below the proper signal response. Harmonic or image responses may be generated by this type of signal, but these will also be at lower amplitudes.

2-36. Spurious Responses. There are two sources of spurious responses generated in any spectrum analyzer; these are (1) intermodulation (IM) products, which are usually generated in the i-f section, and (2) first mixer spurious, a form of IM, which is caused by high level signals overdriving the first mixer.

2-37. Two types of IM products may occur - single tone and two tone - both producing spurious responses that are mathematically related to the signal and/or local oscillator frequencies. Single tone IM occurs when a high level signal in the i-f mixes with the harmonic of a local oscillator (see figure 2-8a). Two tone IM occurs when two high level signals in the i-f encounter a slightly non-linear element (see figure 2-8b). In both cases the IM products are typically greater than 60 dB down when the bandwidth is 10 kHz. Reduction of the bandwidth will also improve the IM products at almost the same rate that the sensitivity is increased, provided that the input signal level is similarly reduced.

2-38. High level signal applied to the first mixer may also generate spurious responses. These are also IM products and are mathematically related to signal and/or local oscillator frequencies. Due to the broad bandwidth of the mixer, the relationship may be very obscure. In either case, spurious responses occur at input signal levels typically greater than -30 dBm. Amplitude non-linearity will not show up until signal levels are greater than -15 dBm; this level is generally specified as the point at which 1-dB compression of the signal occurs. Since the spurious responses are generated by high level signals, reduction of the input signal level and a corresponding improvement in sensitivity will result in a greater spurious-free dynamic range. Figure 2-9 permits the operator to determine the maximum linear dynamic range and maximum spurious-free dynamic range of the analyzer as a function of i-f bandwidth. Note that reduction of the i-f bandwidth and/or sweep speed improves the dynamic range.

2-39. Narrow Width, High Amplitude Pulse Response. Very narrow pulses (approximately 0.01 microseconds) of high amplitude may produce a video pulse in the first mixer ("foldover" will occur with pulses wider than 0.01 usec).

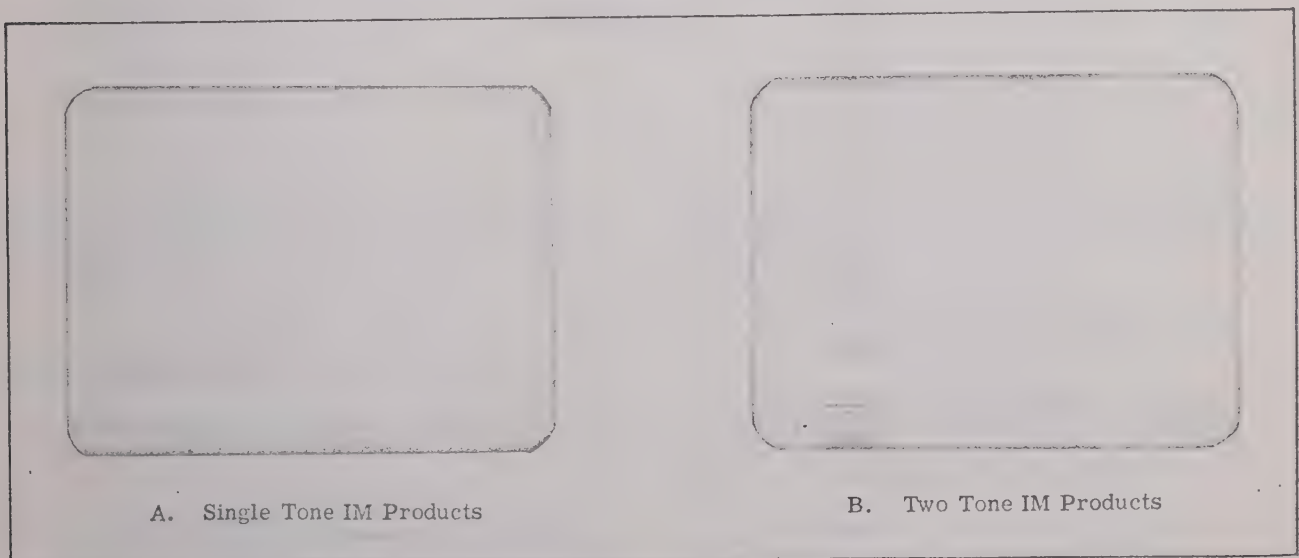
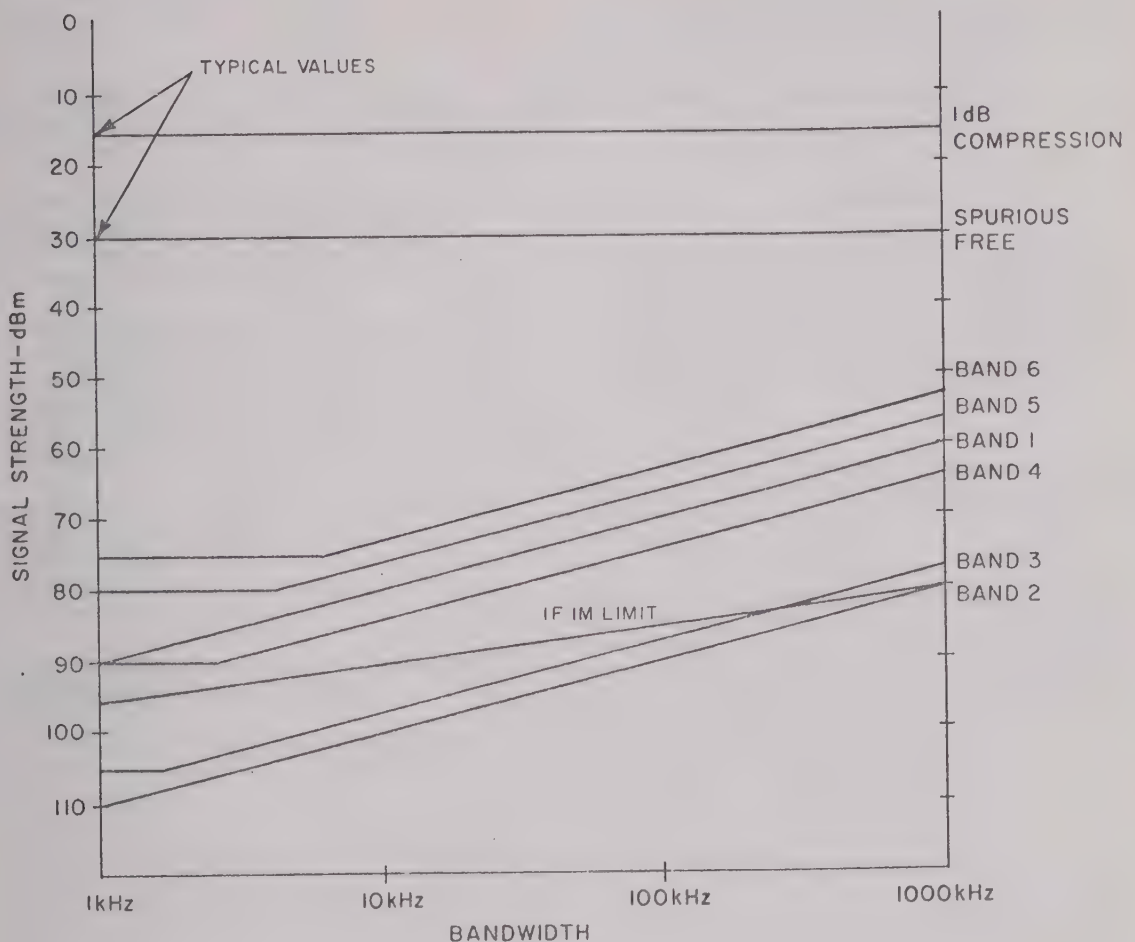


Figure 2-8. Typical Spurious Responses



Example: Determine the maximum dynamic range for both linear and spurious-free operation when the SPA-100 is tuned to 2.0 GHz and set for a bandwidth of 10 kHz.

- Draw a vertical line through the 10 kHz point on the bandwidth axis.
- Note the signal strength where the 10 kHz line crosses the Band 2 line (-100 dBm).
- The maximum linear dynamic range is the difference between the 1-dB compression point (-15 dBm) and -100 dBm: 85 dB.

d. The maximum spurious-free dynamic range of the first mixer is the difference between the maximum spurious-free operating point (-30 dBm) and -100 dBm: 70 dB.

e. Note the signal strength where the 10 kHz line crosses the IF IM LIMIT line (-90 dBm).

f. The maximum spurious-free dynamic range of the i-f circuitry is the difference between the maximum spurious-free operating point (-30 dBm) and the i-f IM limit (-90 dBm) determined in step e.

g. The maximum spurious-free dynamic range is the lesser of d or f; in this case 60 dB.

Figure 2-9. Maximum Linear and Spurious-free Dynamic Ranges as a Function of Bandwidth

This video pulse (see figure 2-10) contains spectral components that will be accepted by the 160-MHz i-f amplifier. Note that most of the first sidelobe and part of the second sidelobe falls within the passband of the 160-MHz wideband i-f amplifier. These components would appear as a stationary display across the full width of the screen

2-40. Local Oscillator Image and Harmonic Response. The origin and frequency of an unidentified pip can be determined as follows:

- a. Set the FREQ DISPERSION switch to 10 MHz/DIV and rotate the FREQ DISPERSION VARIABLE control fully clockwise to CAL. Note that this provides a full calibrated dispersion of 100 MHz.
- b. Rotate the SIGNAL FREQUENCY TUNING control to position the display pip at the extreme right vertical graticule line. Note the frequency indicated on the SIGNAL FREQUENCY 0.94-3.5 GHz dial even though the SIGNAL FREQUENCY RANGE switch may be set to another band.
- c. Rotate the SIGNAL FREQUENCY TUNING control to position the display pip at the extreme left hand vertical graticule line. Again note the frequency indicated by the SIGNAL FREQUENCY 0.94-3.5 GHz dial.
- d. Calculate the difference between the SIGNAL FREQUENCY dial indications of steps b and c.
- e. Calculate the order of the local oscillator harmonic which produces the signal pip by using the equation

$$n = \frac{\text{Dispersion}}{\Delta f}$$

where

n = order of local oscillator harmonic producing the pip,

Δf = difference between SIGNAL FREQUENCY 0.94-3.5 GHz dial indications (in MHz), and

dispersion = calibrated dispersion employed (e.g., 100 MHz)

Note

Round off the calculated value of n to the nearest integer. If n does not have the value of 1, 3, 5, 7 or 11, the signal is heterodyning with an improper local oscillator harmonic and the procedure of steps b through e should be repeated until the proper harmonic is obtained.

f. To check if the pip is an "image" response, compare the direction of pip travel across the screen with respect to the indication of SIGNAL FREQUENCY dial. If the signal pip moves from right to left across the screen as the SIGNAL FREQUENCY dial increases in frequency, the signal is a true signal. Conversely, if the signal moves from left to right across the screen as the SIGNAL FREQUENCY dial indicates higher frequencies, the pip is an image response. To calculate the actual frequency of the applied signal, use the appropriate equation below.

True signal: $f_x = n f_{\text{dial}} + (n-1) 160$

Image response: $f_x = n f_{\text{dial}} + (n+1) 160$

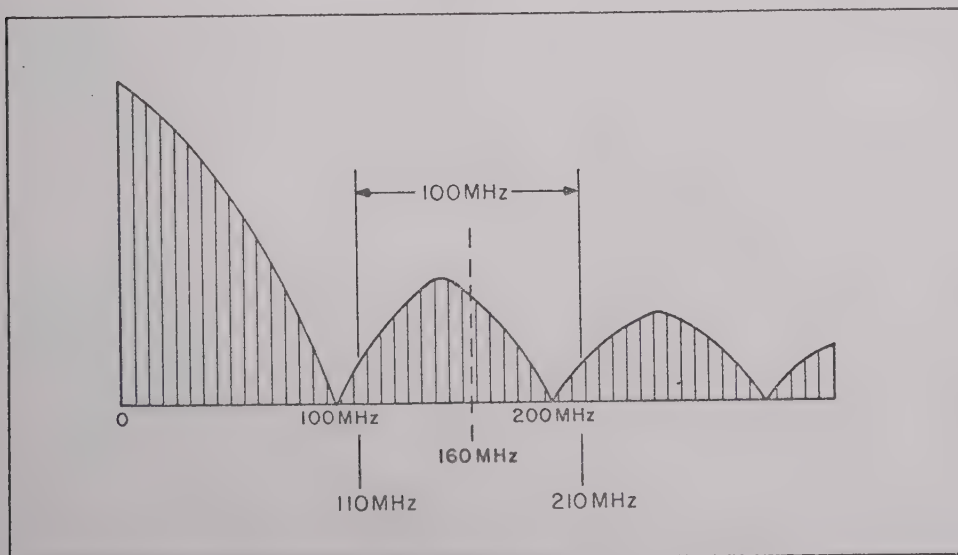


Figure 2-10. Spectrum of a 0.01 Microsecond Video Pulse

where

- f_x = frequency of the unknown signal, in MHz,
 f_{dial} = SIGNAL FREQUENCY 0.94-3.5 GHz dial indication (in MHz) when the signal pip is located at the center of the screen, and
 n = local oscillator harmonic determined in step e.

g. Once the frequency of the unknown signal has been established, set the SIGNAL FREQUENCY RANGE to the appropriate band and adjust the SIGNAL FREQUENCY TUNING control to the frequency calculated above center the pip in the screen.

2-41. **Signal Harmonic Response.** If it has been determined that the pip on the screen is not caused by a harmonic response of the first local oscillator, it is possible that the pip is some harmonic of the applied signal. This possibility may be due to either a harmonic component within the signal itself or the generation of a harmonic by the overdriving of the first mixer. In either case, the fundamental signal can be found by tuning the spectrum analyzer to the various sub-harmonics ($1/2$, $1/3$, $1/4$, etc.) of the dial frequency and searching for a signal. If it is necessary to determine the source of the harmonic, either of the following procedures can be employed.

a. Insert a known amount of attenuation between the signal source and the analyzer. (The attenuator response should be flat over the band between the fundamental and harmonic frequencies.) If the harmonic amplitude response decreases by the same amount as the fundamental, the harmonic is a signal component. If, however, the harmonic response decreases at a much greater amount than does the fundamental, the harmonic is produced by overdriving the crystal mixer of the analyzer.

b. Insert a high-pass filter between the signal source and the analyzer. This eliminates the fundamental response but has a negligible effect on the harmonic if the harmonic is a part of the signal. If the harmonic component is eliminated, it was caused by overdriving the crystal mixer of the analyzer.

2-42. APPLICATIONS.

2-43. **AM MEASUREMENTS.** The amplitude vs. frequency display of the analyzer is useful in determining the percentage modulation of applied amplitude-modulated signals. The percentage modulation can be determined by using the LIN scale and adjusting the carrier pip amplitude for a full scale display (1 on the LIN scale). Once this has been accomplished, note the relative amplitude of one sideband with respect to the carrier. The percentage modulation is equal to twice the relative amplitude of the sideband to the carrier. Thus, if the carrier amplitude is five divisions high (1.0 on the LIN scale) and the sideband amplitude is one division high (.2 on

the LIN scale), the percentage modulation is equal to $2 \times 0.2/1 = 40\%$.

2-44. **FM MEASUREMENTS.** The deviation and modulation index of frequency modulated signals can be readily deduced from the relative levels of the carrier and sidebands using the Bessel function coefficients of the series expansion for an f-m signal (see Panoramic Analyzer, Volume 1, No. 4 for FM measurement techniques). Deviations of transmitters and signal generators are frequently measured by varying the modulation frequency until the first carrier null is obtained. The deviation is then obtained by multiplying this modulating frequency by 2.4. This is the most accurate practical method of measuring deviation and actual band occupancy of the sidebands. This dynamic analysis also has the advantage of the revelation of second order effects (such as residual AM) which causes asymmetry of the sidebands. To determine the deviation of an FM signal generator or transmitter, proceed as follows.

a. Couple the spectrum analyzer to the signal generator or transmitter under test. Be sure that the maximum input level to the analyzer is not exceeded.

b. With the signal generator or transmitter unmodulated, tune the spectrum analyzer to center the carrier frequency on the screen.

c. Couple a source of modulation to the signal generator or transmitter; set the modulator to a suitable frequency and minimum output level. Note that the modulation frequency should be greater than the selected analyzer bandwidth.

d. Slowly increase the modulator output amplitude until the carrier amplitude decreases to its first null. (It may be necessary to remove inserted i-f attenuation and/or increase the IF GAIN control setting to provide maximum sensitivity when observing the first carrier null.) When the first carrier null is attained, the modulation index is 2.4 and the deviation is 2.4 times the frequency of the modulating frequency. Higher order carrier nulls and/or sideband nulls can be evaluated using Bessel tables.

2-45. **PULSE ANALYSIS.** The characteristics of pulsed r-f signals can be analyzed and the pulse width measured from the amplitude versus frequency display presented during spectrum analyzer operation. Many of the pulse characteristics can be verified by converting the analyzer to a synchroscope by setting the SWEEP switch and SWEEP SYNC switch to the appropriate red settings. The pulse width, incidental am and pulse repetition rate can then be measured directly from the synchroscope display. (See figure 2-11.) To obtain a synchroscope (time domain) display of the pulsed r-f signal, first obtain a convenient spectrum analyzer display and then continue as directed below.

a. Set the FREQ DISPERSION switch to 0.

b. Adjust the SIGNAL FREQ POSITION f_0 COARSE and/or FINE control to obtain a maximum amplitude display on the CRT.

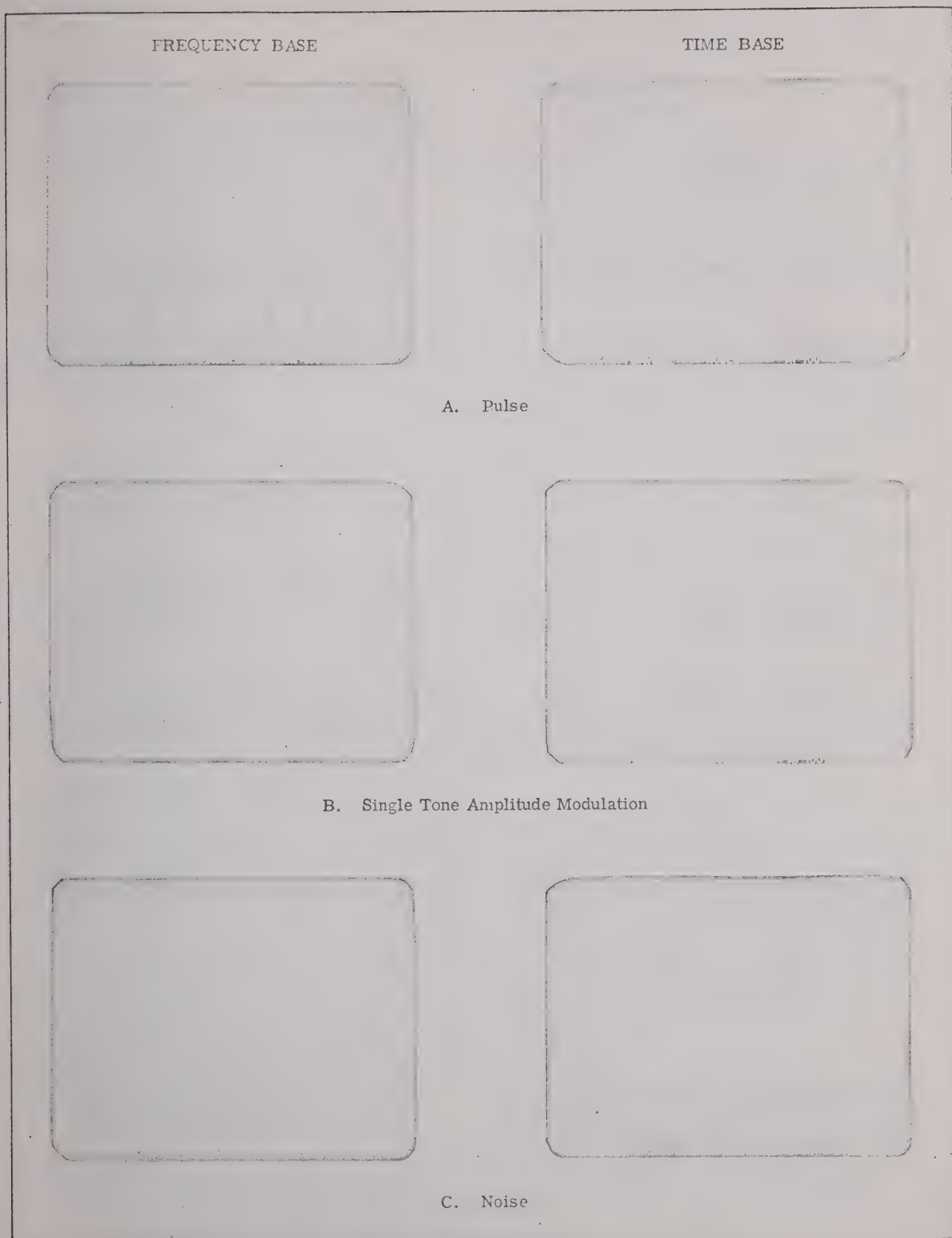


Figure 2-11. Comparison of Frequency-base and Time-base Displays

Section II Operation

c. Set the SWEEP switch to any of the red USEC/DIV positions.

d. If the sweep is to be synchronized internally by the detected video signal, set the SWEEP/SYNC switch to INT SYNC (red). If the sweep is to be synchronized by an external pulse, couple the synchronizing pulse between pins D (EXT SYNC INPUT) and M (GND) of rear panel connector J1 and set the SWEEP/SYNC switch to EXT SYNC (red).

e. Set the BANDWIDTH switch to 1000 kHz.

f. Ascertain that the MARKER MODULATION switch is set to OFF and that the MARKER LEVEL control is rotated fully counterclockwise to OFF.

g. Set the AMPLITUDE SCALE switch for the desired presentation. The amplitude of the displayed pulse can be adjusted by changing the setting of the IF ATTENUATOR switches.

Note

Do not adjust the setting of the SIGNAL FREQUENCY TUNING control once in synchroscope operation. Slight retuning of the first local oscillator will cause distortion or loss of signal.

2-46. CHECKS OF RADAR SET PERFORMANCE. The spectrum analyzer can be coupled (via directional couplers or an antenna) to a radar set to evaluate its operation.

a. The radar output pulse can be observed on the spectrum analyzer to determine pulse width, pulse repetition rate, incidental AM and FM, mode failures and relative sidelobe amplitude and symmetry.

b. The energy distribution in the transmitted pulse can be determined and used as the basis for receiver bandwidth design. Should the receiver bandwidth be too narrow, the pulse shape will not be preserved and the radar accuracy will be compromised. Conversely, increasing the receiver bandwidth beyond the point of optimum energy reception serves no useful purpose and will decrease the signal-to-noise ratio.

c. Receiver afc can be checked by displaying both the magnetron output and the local oscillator frequency simultaneously. Because the magnetron is pulsed, a typical pulsed r-f pattern will represent the magnetron output. The receiver local oscillator output, however, will be represented by a single pip displaced from the center of the pulsed pattern by the i-f frequency. Any magnetron pulling resulting from antenna rotation should produce a corresponding shift in local oscillator frequency.

d. TR boxes may be tuned accurately to the magnetron frequency by first tuning the spectrum analyzer so that the magnetron frequency is centered on

the display. Then, with the magnetron turned off and an impulse generator applied to the TR box, the spectrum analyzer will display the frequency response characteristics of the TR box and the TR box can then be tuned so that its center frequency is the same as the magnetron.

2-47. ANTENNA PATTERNS. An X-Y plot of antenna patterns can be obtained by using the spectrum analyzer as an r-f voltmeter and by having the analyzer sweep synchronized to the antenna rotation.

a. With the analyzer adjusted for a LOG display, couple the antenna under test to the appropriate input connector. The antenna should be installed on a rotating platform and directed toward a transmitting antenna.

b. Tune the spectrum analyzer to the transmitted frequency. Once the analyzer is tuned to the frequency of transmission, set the FREQ DISPERSION switch to 0 and carefully adjust the SIGNAL FREQUENCY TUNING control to obtain a maximum display amplitude.

c. Set the SWEEP/SYNC switch to SINGLE and set the SWEEP switch to 1000 MS/DIV.

d. Couple an external x-y recorder to the appropriate terminals of rear panel connector J1.

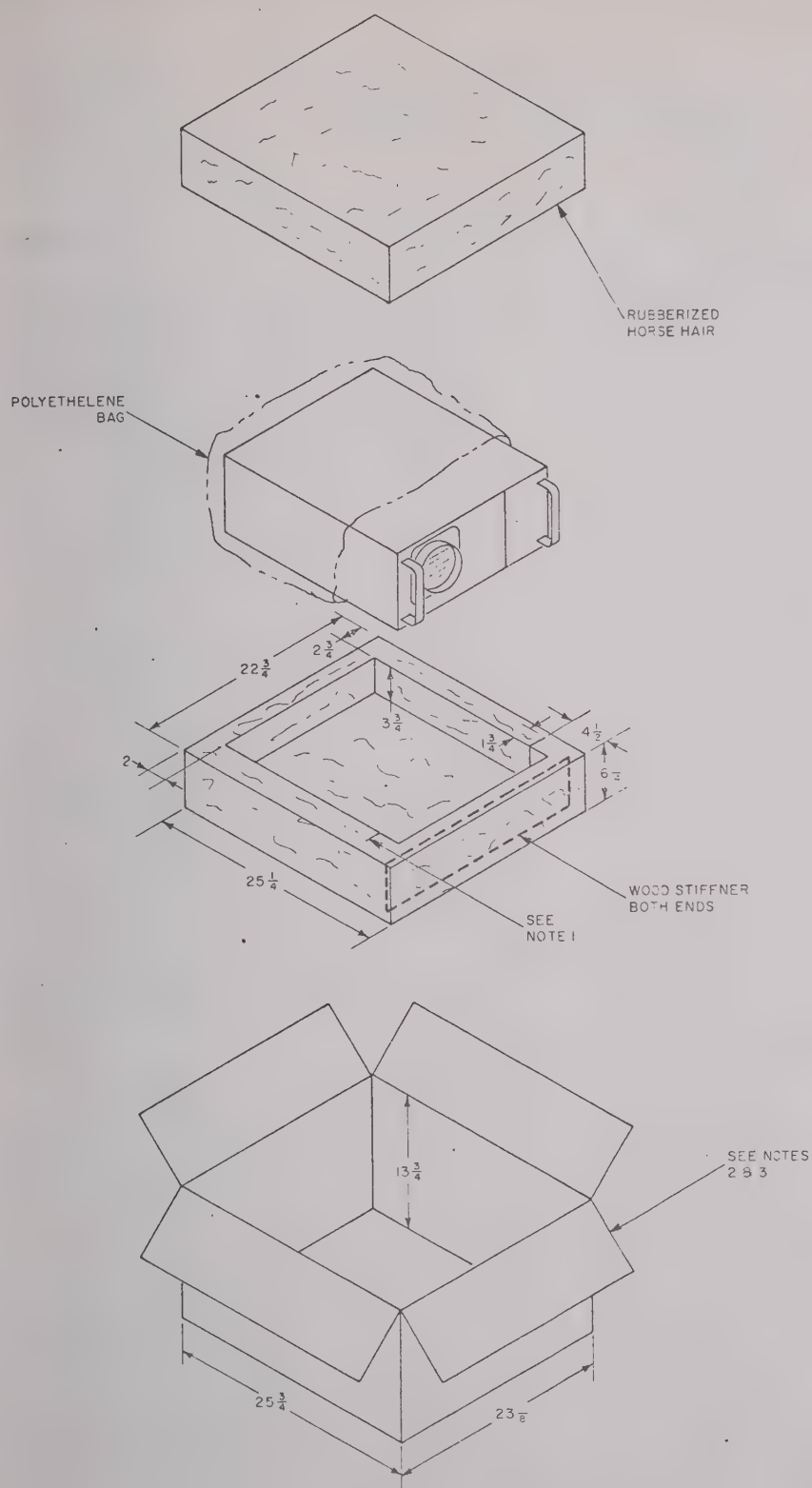
e. Rotate the antenna at a speed slightly faster than 6 revolutions per minute so that one complete antenna revolution will be completed within the time for one sweep.

f. When the antenna is directed away from the transmitting antenna, depress the SINGLE pushbutton switch. In this manner the main lobe of the antenna pattern will appear approximately centered on both the CRT and recorder.

2-48. RFI MEASUREMENTS. Spectrum analyzers are extremely useful when used in conjunction with RFI meters to help locate and identify the nature of the signal to be measured by the RFI meter. Except for approximate measurements, a spectrum analyzer cannot replace an RFI meter to determine absolute signal levels. On the other hand, the very narrow window of the RFI meter makes it impractical for locating signals (scanning) and the meter indications of an RFI meter are not as conclusive as a spectrum analyzer display for evaluating the type of signal being measured.

2-49. PACKAGING.

2-50. Figure 2-12 illustrates the method of packaging the analyzer for long term storage or shipment. For short term storage, use a suitable protective covering (such as a sheet of paper or plastic) and store the instrument in a clean and dry area. Store accessories and instruction manual in a carton or bag and fasten to the equipment to avoid loss.



- NOTES
1. MAKE THIS SLOT WHEN UNIT IS SHIPPED WITH RACK MOUNT EARS
 2. ALL CARTON DIMENSIONS ARE IN INCHES
 3. CARTON MUST WITHSTAND 1000 LB PUNCTURE TEST

Figure 2-12. Packaging Diagram

SECTION III THEORY OF OPERATION

3-1. GENERAL.

3-2. The RF-100 and RF-100A are multiband tunable front ends which heterodyne either the fundamental or a harmonic of a tunable internal local oscillator with an applied r-f signal to produce an intermediate-frequency output signal centered at 160 MHz. This 160-MHz i-f signal is then coupled to the MF-100 where it is further processed to provide a visual amplitude-frequency (spectrum analyzer) or amplitude-time (synchroscope) display of the applied r-f signal.

3-3. DETAILED THEORY OF OPERATION (See Figures 3-1, 5-1 and 5-3).

3-4. SIGNAL PATH, 0.94 TO 11 GHZ. When the RF-100 or RF-100A SIGNAL FREQUENCY RANGE switch is set to either .94-3.5 GHz or 3.2-11 GHz, the r-f signal under analysis is coupled through SIGNAL INPUT 1-11 GHz connector CP1 and applied to crystal diode CR1 within mixer assembly A1. R-f energy from a tunable triode local oscillator (refer to paragraph 3-9) is simultaneously applied to the diode mixer through the normally closed contacts of unenergized relay K1 and 6-dB attenuator AT1. Since the diode is a non-linear device, its output will be composed of a negative d-c level, the applied r-f signal, the local oscillator signal as well as the sum and difference products of the applied r-f signal and local oscillator fundamental frequencies and harmonics. When properly tuned, the local oscillator fundamental or harmonic is 160 MHz above the incoming r-f signal.

3-5. 160-MHZ PREAMPLIFIER A2. The composite output of the 0.94-11 GHz crystal mixer is coupled to the primary winding of transformer T1. The low-impedance transformer primary winding passes the negative d-c component of the crystal mixer output (through the low pass filter consisting of C1, L1 and FL2) to level amplifier A6 (refer to paragraph 3-10). The broadly tuned secondary of T1 passes the 160-MHz difference (i-f) frequency of the mixer while simultaneously attenuating the local oscillator component, the applied signal component, the sum frequency component as well as the sum and difference frequency products of their harmonics. That band of signals between 110 and 210 MHz is amplified by Q1 and coupled through a 2-dB pad (R4, R5 and R6) and J2 to the input of the MF-100 via the normally-closed contacts of unenergized relay K2.

3-6. SIGNAL PATH, 11 to 40 GHZ. When the RF-100 or RF-100A SIGNAL FREQUENCY RANGE switch is set to 11-18 GHz, 18-26 GHz or 26-40 GHz, the local oscillator output is coupled through the

closed contacts of energized relay K1 and 6-dB pad AT3 to frequency selective "T" A4. The high-pass leg of the "T" (that which contains C1) passes the local oscillator signal through SIGNAL INPUT connector CP2 to an external waveguide mixer. The r-f signal under analysis, which is simultaneously applied to the external waveguide mixer, heterodynes with the local oscillator output. The non-linear characteristics of the mixer diode produces an output which consists of a negative d-c level, the applied r-f signal, the local oscillator signal as well as the sum and difference products of the applied r-f signal and local oscillator fundamental frequencies and harmonics. When properly tuned, the local oscillator harmonic (see table 3-1) is 160 MHz above the incoming r-f signal.

3-7. 160-MHZ PREAMPLIFIER A5. The composite output of the external mixer is returned to the frequency selective "T" and coupled to 160-MHz preamplifier A5. The negative d-c crystal current component and the 160-MHz difference frequency component are transmitted through the low-pass leg of the "T" (that leg which contains L1) to 160-MHz preamplifier A5. The negative d-c crystal current is passed through a low-pass filter (L1 and FL2) and applied to level amplifier A6. The 160-MHz difference frequency component is coupled through a broadly tuned matching network to Q1 and, after undergoing amplification, is fed through a 2-dB pad (R6, R7 and R8) and J2 to the input of the MF-100 via the closed contacts of energized relay K2.

3-8. SIGNAL PATH, 0.01 to 1 GHZ. When the RF-100 SIGNAL FREQUENCY RANGE switch is set to .01-1 GHz, the r-f signal under analysis is coupled through SIGNAL INPUT .01-1 GHz connector CP4 and applied to diode CR1 within mixer assembly A7. R-f energy from a fixed frequency 2.5-GHz oscillator chain (refer to paragraphs 3-13 through 3-15) is simultaneously applied to the mixer through 6-dB pad AT4. The d-c output of the mixer is shorted to ground by the shunt inductor in CP3 while all other signal and heterodyne products are coupled through isolator AT2, 2.5-GHz trap FL1 and band-pass filter FL2 to UP CONVERTER OUTPUT connector J1. The 2.5-GHz component of the mixer output is attenuated by 2.5 GHz trap FL1 while the applied signal component and all heterodyne products other than the desired sum frequency signal are attenuated by bandpass filter FL2. The upconverted (2.51 to 3.5 GHz) signal is then coupled between the UP CONVERTER OUTPUT connector to the SIGNAL INPUT 1-11 GHz connector where it is processed as described in paragraph 3-4. Note that isolator AT2 provides a minimum of 20 dB isolation between the tunable local oscillator output (refer to paragraph

TABLE 3-1. TRIODE LOCAL OSCILLATOR CHARACTERISTICS

SIGNAL FREQUENCY RANGE Switch Setting	Triode Local Oscillator Frequency Range	Local Oscillator Harmonic Employed	Harmonic Frequency Range
.01-1 GHz	2.67 to 3.66 GHz	Fundamental	---
.94-3.5 GHz	1.10 to 3.66 GHz	Fundamental	---
3.2-11 GHz	1.12 to 3.72 GHz	3rd	3.36 to 11.16 GHz
11-18 GHz	2.23 to 3.63 GHz	5th	11.16 to 18.16 GHz
18-26 GHz	2.59 to 3.74 GHz	7th	18.16 to 26.16 GHz
26-40 GHz	2.37 to 3.65 GHz	11th	26.16 to 40.16 GHz

3-9) and mixer diode A7CR1, thereby minimizing the generation of spurious responses and IF feedthru when the RF-100 is operating in this band.

3-9. TRIODE LOCAL OSCILLATOR A3. Local oscillator power for heterodyning with the applied r-f signal is obtained from ceramic triode VI operating in an integral tunable dual cavity. The triode and cavities combine to form a tuned-plate tuned-cathode oscillator and the frequency of oscillation is determined by the physical length of the plate and cathode cavities. The physical length of both cavities is determined by the setting of the SIGNAL FREQUENCY TUNING control. Output power is extracted from the plate cavity by probe coupling. The frequency range, harmonic employed and harmonic frequency range of the tunable local oscillator as a function of the selected tuning band are listed in table 3-1.

3-10. LEVEL AMPLIFIER A6. Conventional tunable local oscillators have output level variations that are a function of operating frequency. These variations cause the first mixer d-c output current to fluctuate as a function of frequency and consequently does not permit the diode to be operating at its optimum point. The circuitry of level amplifier A6 keeps the crystal current output of the mixer constant across the band, thereby obtaining optimum sensitivity and flatness of response throughout the band.

3-11. Assume that the SIGNAL FREQUENCY RANGE switch is set to .94-3.5 GHz and that the SIGNAL FREQUENCY TUNING control is adjusted to obtain a SIGNAL FREQUENCY dial indication at the low end of the band (.94 GHz). The d-c crystal current component of mixer A1CR1 is coupled through closed contacts W2 and 8 of S1B and closed contacts W1 and 2 of S1C across R9 to establish base to ground voltage at difference amplifier A6Q3. The base bias of A6Q2 is adjusted by Band 2 screwdriver control R4 so that collector current of A6Q1 sets the plate-to-cathode voltage of A3V1 (hence the oscillator output level) at that value which will provide an optimum crystal current of 1 milliamperere. Should the output level of the oscillator change as it is tuned

to another frequency, the change in crystal current will be sensed by difference amplifier A6Q3/A6Q2, causing the collector current of A6Q1 to change in that direction which causes the local oscillator output level to shift and return the crystal current to the optimum level of 1 ma.

3-12. 2.5-GHZ FIXED LOCAL OSCILLATOR. The 2.5-GHz signal required to supply local oscillator power for the up-converter in the RF-100 is obtained from a 104.167-MHz oscillator and frequency tripler (refer to paragraph 3-14) whose output is then multiplied up to 25 GHz (refer to paragraph 3-15).

3-13. 104.167-MHz Oscillator-Frequency Tripler A9. When the SPA-100 is operating in the .01-1 GHz band, +12 and -12 volts are supplied to 104.167-MHz oscillator-frequency tripler A9 (see figure 5-2). Grounded-base amplifier A1Q1, in conjunction with the positive feedback path through crystal A1Y1, provides a 104.167-MHz output which is coupled through buffer amplifier A1Q2 to frequency tripler A2Q1. The frequency tripler, which is biased to operate in its non-linear region, produces an output that is rich in harmonics. The fundamental and second harmonic components of the tripler output are shunted to ground by means of the resonant circuits consisting of A2L4 and A2C7 and A2L5 and A2C8. The series resonant circuit of A2L6 and A2C9 passes the 312.501-MHz third-harmonic component while simultaneously attenuating all higher-order harmonics. The 312.501-MHz signal is coupled through a 3-dB pad (A2R3, A2R4 and A2R5) to buffer amplifier and frequency multiplier A8.

3-14. Buffer Amplifier and Frequency Multiplier A8. The 312.501-MHz output of A9 is coupled to buffer amplifier Q1 of A8. The buffer amplifier, which is a grounded-base amplifier, drives a step recovery diode frequency multiplier. The frequency multiplier consists of harmonic generator CR1 operating in a tunable coaxial cavity. The cavity, which is tuned to 2.5 GHz, passes the eighth harmonic (while attenuating all other responses) through coupler CP5 to bandpass filter FL3. FL3 is tuned to 2.5 GHz and therefore passes only the desired

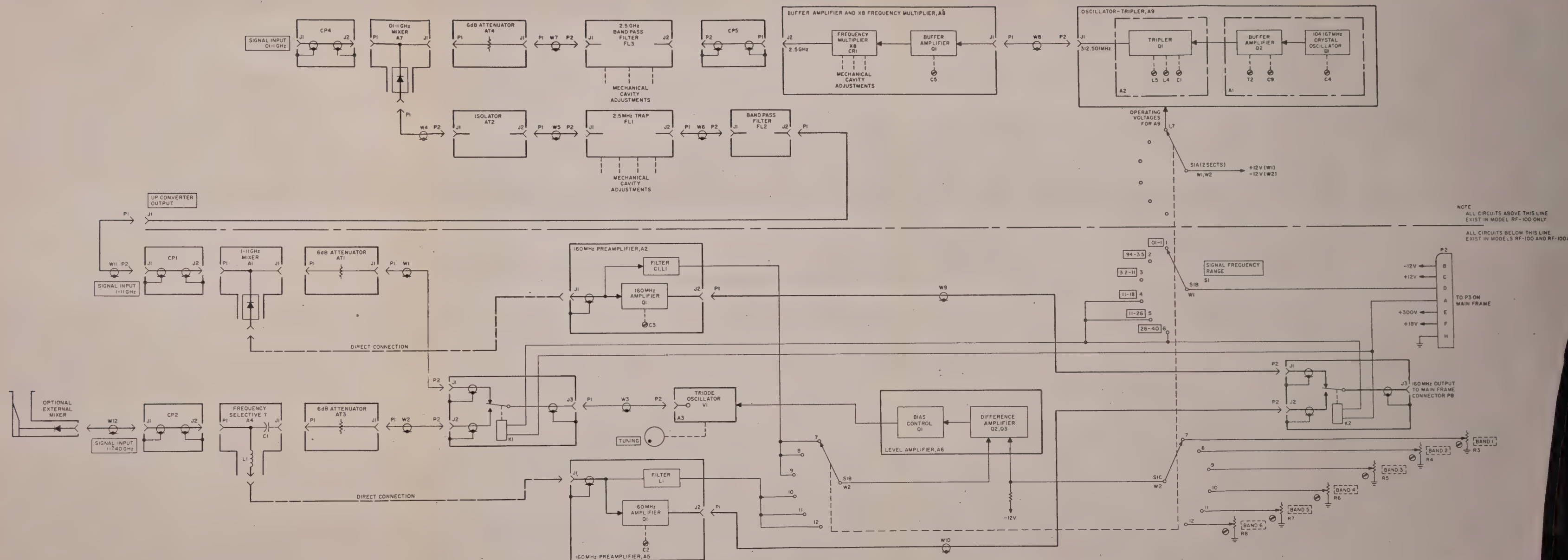


Figure 3-1. RF-100 and RF-100A
Detailed Block Diagram

eighth harmonic of the harmonic generator further suppressing the other harmonics to upconverting mixer A7CR1.

3-15. POWER DISTRIBUTION. All power required for the operation of the RF-100 and RF-100A is derived from the MF-100 through multipin connector P2 on the tuning head.

SECTION IV MAINTENANCE

4-1. GENERAL.

4-2. This section contains maintenance, alignment and calibration instructions for the RF-100 and RF-100A. Included are a list of test equipment, minimum performance standard checks to determine whether the equipment operates within the limits of published specifications, systematic troubleshooting procedures localizing malfunctions to an individual subassembly or circuit, and alignment and calibration

procedures necessary to restore the equipment to proper operating condition after the required repairs have been effected.

4-3. TEST EQUIPMENT REQUIRED.

4-4. The test equipment required for the maintenance, alignment and calibration of the equipment is listed in table 4-1. Equipment with similar characteristics may be substituted for any item listed in the table.

TABLE 4-1. REQUIRED TEST EQUIPMENT

Manufacturer	Nomenclature
Hewlett-Packard	Models 608D, 612, 614A, 616B, 618C, 620B, 626A and 628 Signal Generators
Hewlett-Packard	Models 938A and 940A Frequency Doublers
Hewlett-Packard	Model 536A Wavemeter
Hewlett-Packard	Model 423A Detector
Simpson	Model 260 Multimeter
Hewlett-Packard	Model 8406A Comb Generator
Hewlett-Packard	Model HP130C Oscilloscope
Singer Metrics	Model AT-100 R-f Attenuator Set
Hewlett-Packard	Model 430C Power Meter
Hewlett-Packard	Model 477B Thermister Mount
Singer Metrics	Model SPA-100 Spectrum Analyzer
Microlab	Model HC-10N Sampler
Hewlett-Packard	Model 692D Sweep Generator
Hewlett-Packard	Model 536A Frequency Meter
Hewlett-Packard	Model 423A Negative Polarity Crystal Detector
Weinschel	Model 953 Variable Attenuator
Airborne Instrument Lab	Type 391 Microwave Crystal Test Set

4-5. MINIMUM PERFORMANCE STANDARDS.

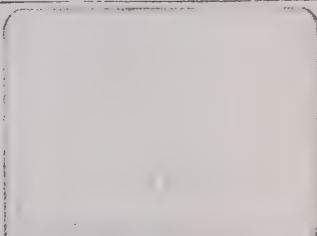
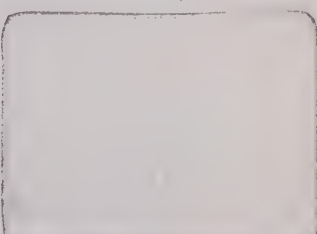
4-6. The minimum performance standards checks of table 4-2, when performed, determine whether the equipment is functioning within the specifications listed in Section I. If the equipment fails to provide

the "acceptable indication" specified, the operator should refer to the applicable troubleshooting, replacement, repair, alignment and calibration procedures to correct the defect. Energize the equipment as described in paragraph 2-11. The test setup for these checks is illustrated in figure 4-1.

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS

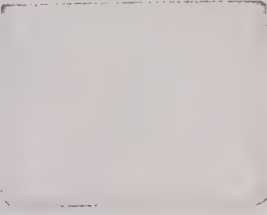
Step	Purpose	Procedure	Acceptable Indication
1	To set up the unit for testing	Set the following controls as indicated: SCALE ILLUMINATION cw FOCUS mid BRIGHTNESS cw INTENSIFIER ccw IF ATTENUATOR 00dB FREQ DISPERSION 1. Step .3 MHz/DIV 2. VAR CAL MARKER 1. MODULATION OFF 2. LEVEL CW AMPLITUDE SCALE LIN IF GAIN mid SIGNAL FREQ POSITION 1. COARSE mid 2. FINE mid BANDWIDTH 1. Step 100 kHz 2. VAR CW SWEEP 1. Step 3MS/DIV 2. VAR CAL SWEEP/SYNC INT SWEEP Note Models RF-100 and RF-100A require a warm up of 10 minutes before attempting to adjust any controls. Adjust the FOCUS and BRIGHTNESS controls. Adjust the H POS control. Adjust the V POS control.	A clearly-visible sharply focused trace. Center the trace. Offset the trace approximately 2 divisions from the base line.

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication																												
		Adjust the H SIZE control.	The trace should extend 1/4 division beyond each side of the calibrated screen.																												
		Readjust V POS control.	Set the trace coincident with the baseline.																												
		Adjust SIGNAL FREQ POSITION control.	Center the pip on the screen.																												
2	To check the frequency accuracy of the unit.	Using the test set up of figure 4-1 with no signal generator input, set the RANGE switch to 11-40 GHz, and using the .94 to 3.5 GHz scale of the tuning head, measure the frequency of the local oscillator at the 11-40 GHz SIGNAL INPUT jack of the unit under test, at different points on the band.	The observed local oscillator should be 160 MHz above the indicated signal frequency on the tuning dial, $\pm 1\%$.																												
3	To check the sensitivity of the unit.	Connect a signal generator, through a 10 dB attenuator (see figure 4-1) to the appropriate SIGNAL INPUT jack for the applied frequency. Using the Main Frame internal markers, obtain a display centered on the CRT screen with the trace positioned on the lowest graticule line. Set the SIGNAL FREQUENCY RANGE switch to the desired band. Adjust the SIGNAL FREQUENCY TUNING control to obtain the test frequency indication on the SIGNAL FREQUENCY dial; fine tune to position the signal in the center of the CRT display. Adjust the IF GAIN control to obtain a display of noise whose peaks average .2 on the LIN scale of the graticule. Reduce the signal generator output level to obtain a pip peak coincident with the LIN scale 0.4 line. That is, signal (S) plus noise (N) equals twice noise (2N). To reduce errors caused by operator interpretation of the noise display, adjust the BANDWIDTH VARIABLE control fully ccw to obtain an easily discernable S+N = 2N display. Note the signal generator output level in dBm, the sensitivity is equal to the signal generator output level less the 10 dB loss of the pad and a correction factor as follows: <table><thead><tr><th>Band</th><th>Procedure Freq Range</th><th>Correction Factor</th></tr></thead><tbody><tr><td>1</td><td>.01 to 1 GHz</td><td>20 dB</td></tr><tr><td>2</td><td>.94 to 3.5 GHz</td><td>20 dB</td></tr><tr><td>3</td><td>3.2 to 11 GHz</td><td>18 dB</td></tr><tr><td>4</td><td>11 to 18 GHz</td><td>16 dB</td></tr><tr><td>5</td><td>18 to 26 GHz</td><td>14 dB</td></tr><tr><td>6</td><td>26 to 40 GHz</td><td>12 dB</td></tr></tbody></table> (See NOTE following this table) Check the sensitivity of the set at 0.1 GHz intervals for band 1; 0.25 GHz intervals for band 2; 0.5 GHz intervals for band 3; 1.0 GHz intervals for band 4 and 5; and 2.0 GHz for band 6.	Band	Procedure Freq Range	Correction Factor	1	.01 to 1 GHz	20 dB	2	.94 to 3.5 GHz	20 dB	3	3.2 to 11 GHz	18 dB	4	11 to 18 GHz	16 dB	5	18 to 26 GHz	14 dB	6	26 to 40 GHz	12 dB	 S + N = 2N (Unfiltered)  S + N = 2N (Filtered) Example: If the set is tuned to 8.0 GHz and the signal generator output level is -79 dBm, the actual sensitivity of the set at 1 kHz bandwidth is -79 dBm - (10 dB + 18 dB) = -107 dBm. <table><thead><tr><th>Sensitivity</th></tr></thead><tbody><tr><td>-90 dBm</td></tr><tr><td>-110 dBm</td></tr><tr><td>-105 dBm</td></tr><tr><td>-90 dBm</td></tr><tr><td>-80 dBm</td></tr><tr><td>-75 dBm</td></tr></tbody></table>	Sensitivity	-90 dBm	-110 dBm	-105 dBm	-90 dBm	-80 dBm	-75 dBm
Band	Procedure Freq Range	Correction Factor																													
1	.01 to 1 GHz	20 dB																													
2	.94 to 3.5 GHz	20 dB																													
3	3.2 to 11 GHz	18 dB																													
4	11 to 18 GHz	16 dB																													
5	18 to 26 GHz	14 dB																													
6	26 to 40 GHz	12 dB																													
Sensitivity																															
-90 dBm																															
-110 dBm																															
-105 dBm																															
-90 dBm																															
-80 dBm																															
-75 dBm																															

(Cont'd)

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
4	To check the incidental FM of band 2.	Connect the comb generator to the 1-11 GHz SIGNAL INPUT and set for a 100 MHz output. Adjust the SIGNAL FREQUENCY TUNING control to center the signal indication of the display. Set the SWEEP control to 1000 us/DIV (red). Set the BANDWIDTH switch to 1 kHz. Reduce the FREQ DISPERSION to 1 kHz/DIV. Measure and record the horizontal jitter of the displayed signal.	1 division or less 

Note

Using the 100 kHz bandwidth instead of the 1 kHz bandwidth in the actual sensitivity measurement removes the inaccuracy caused by the frequency instability of signal generators. Most microwave signal generators have incidental FM's of up to 50 kHz, while the spectrum analyzer has resolving capabilities of 1 kHz. However when the measurement is taken at 100 kHz a correction factor is required. The correction factor is made up of two components: the first is due to the measurement of sensitivities with a 100 kHz bandwidth while the sensitivity specification is with a 1 kHz bandwidth; the second is the minimum resolution limitation due to the incidental FM of the local oscillator.

If a sensitivity measurement is obtained using a bandwidth of 100 kHz, it can be translated, simply, to an equivalent sensitivity measurement taken with a bandwidth of 1 kHz, using the equation:

$$\text{correction factor} = 10 \log \frac{\Delta f \text{ 100 kHz}}{\Delta f \text{ 1 kHz}}$$

This discussion assumes that the spectrum analyzer can resolve 1 kHz, but it can do this only over a portion of the band. The factor that limits the resolving capability of the spectrum analyzer is the incidental FM of the first local oscillator. Any selected bandwidth narrower than the resolving capability of the spectrum analyzer is not useful. Therefore, the correction factor is limited to minimum useful bandwidths equal to the incidental FM of the operating harmonics of the triode local oscillator. The typical incidental FM of the fundamental of the triode local oscillator is 500 Hz. Therefore, for operation on the third and higher harmonics, the spectrum analyzer cannot usefully resolve 1 kHz, and the correction factor for this bandwidth is less than the 20 dB figure obtained from the equation. The proper correction factor associated with any bandwidth useful at a given frequency range, is obtained by substituting the limiting factor of minimum useful resolution, in kHz, for the 1 kHz term in the above expression.

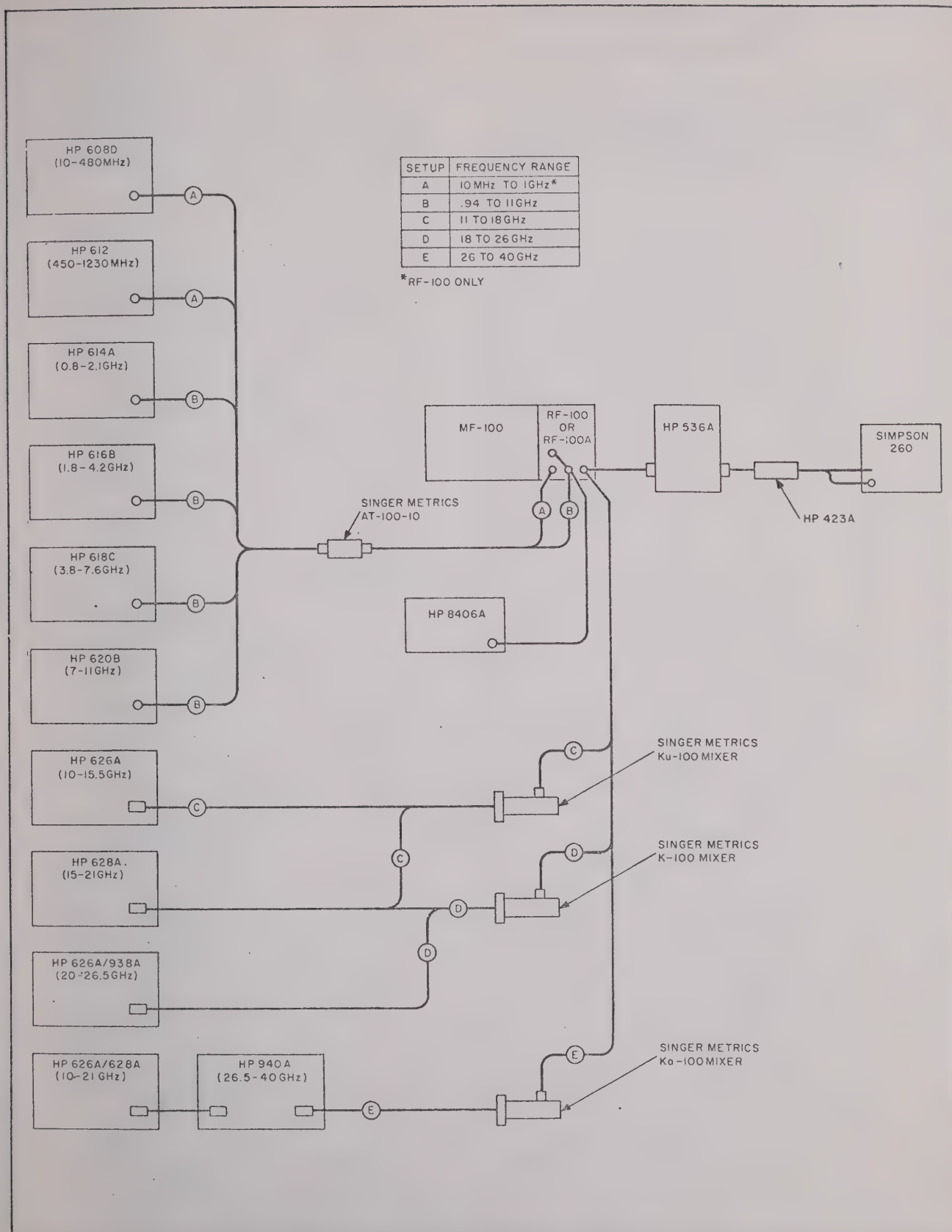


Figure 4-1. Equipment Setup for Minimum Performance Checks

4-7. PRELIMINARY INSPECTION.

4-8. Preliminary inspection of the equipment is performed without operating power applied. The inspection is designed to detect any conditions that if left alone might cause a breakdown. Frequent causes of premature failure are: overheating due to improper ventilation, accumulations of dust and dirt, and/or loose connections and fittings. Inspection is

carried out with emphasis placed upon finding evidence of these conditions.

4-9. COMPONENT LOCATIONS.

4-10. The major components of the equipment, as well as all of the components mentioned in the alignment and troubleshooting procedures supplied in this section, are illustrated in figures 4-2 through 4-7.

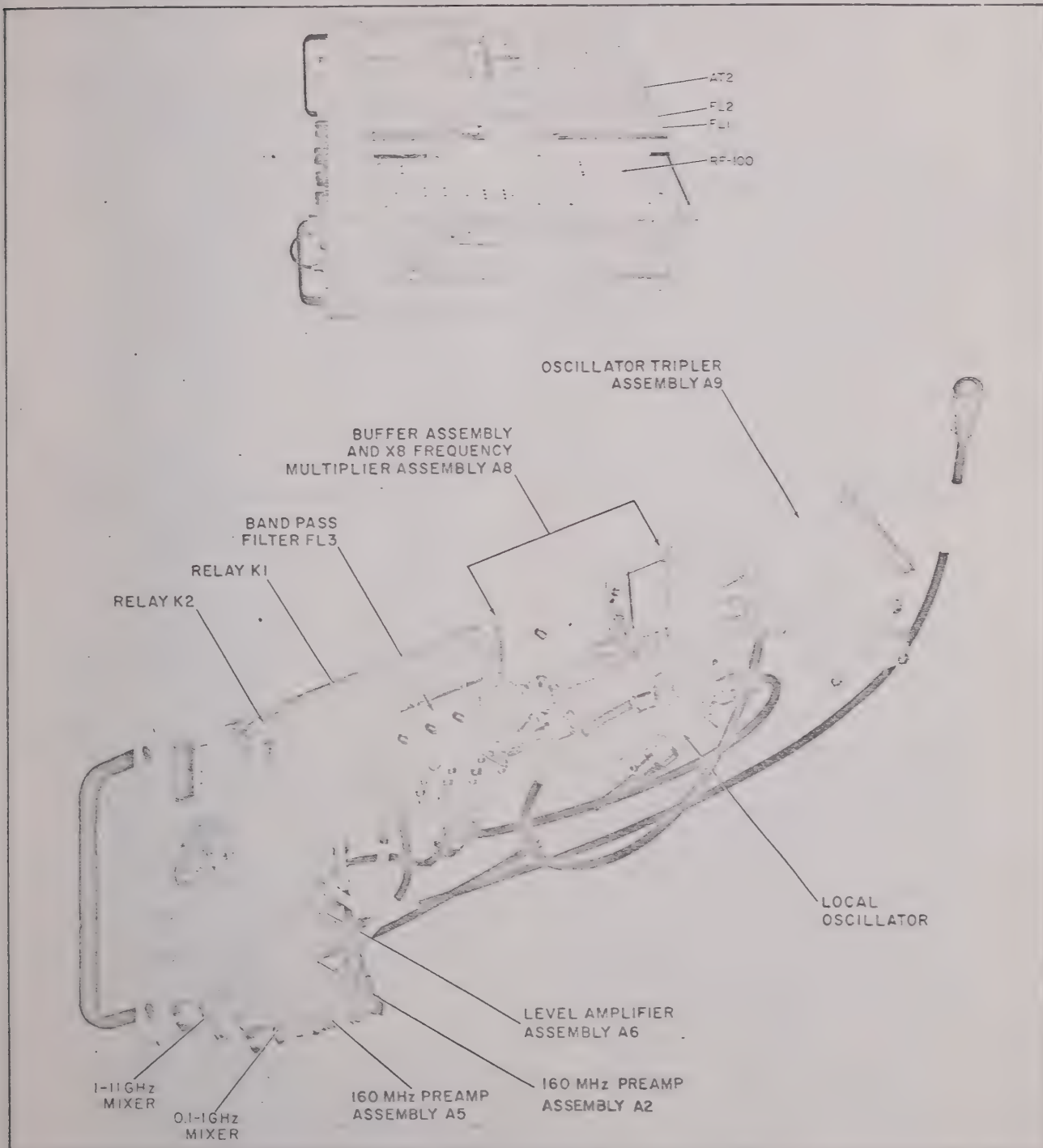


Figure 4-2. Major Assemblies of RF-100

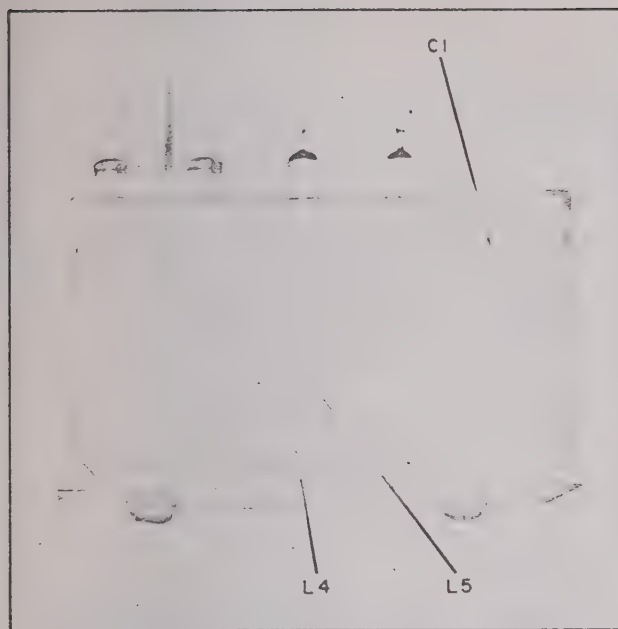


Figure 4-3. Oscillator-Tripler A9
(Tripler Section)

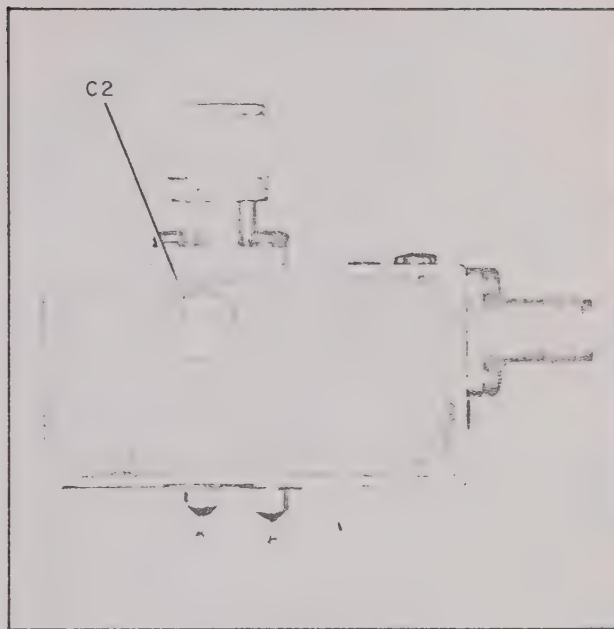


Figure 4-4. 160-MHz Preamplifier A2

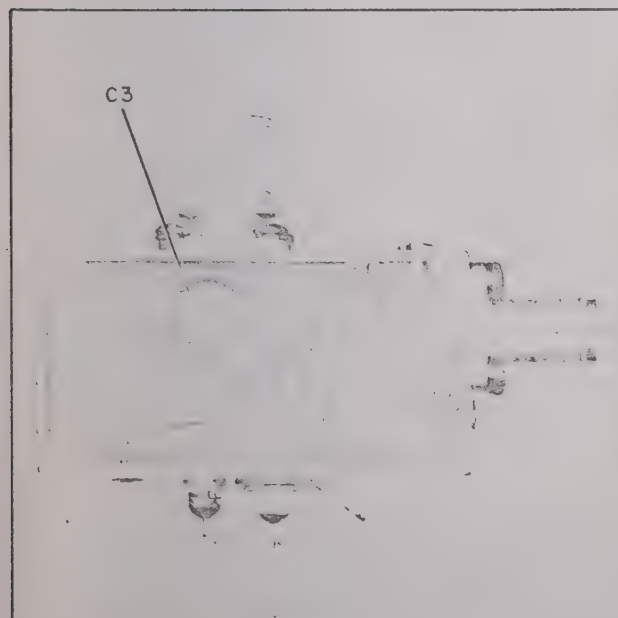


Figure 4-5. 160-MHz Preamplifier A5

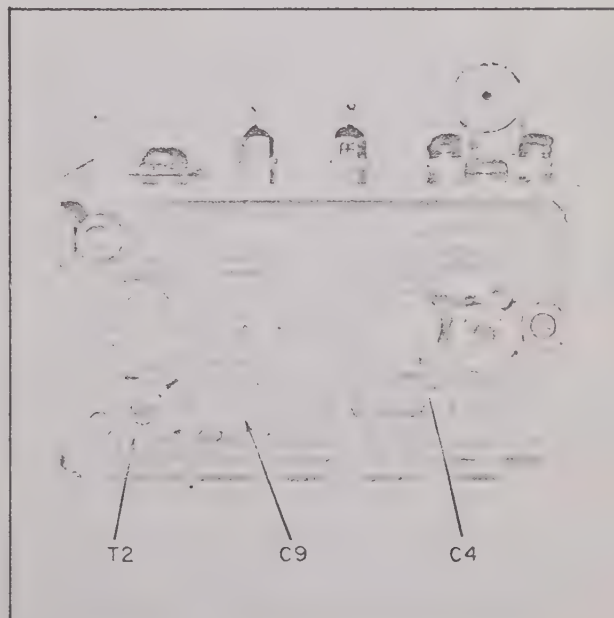


Figure 4-6. Oscillator-Tripler A9
(Oscillator Section)

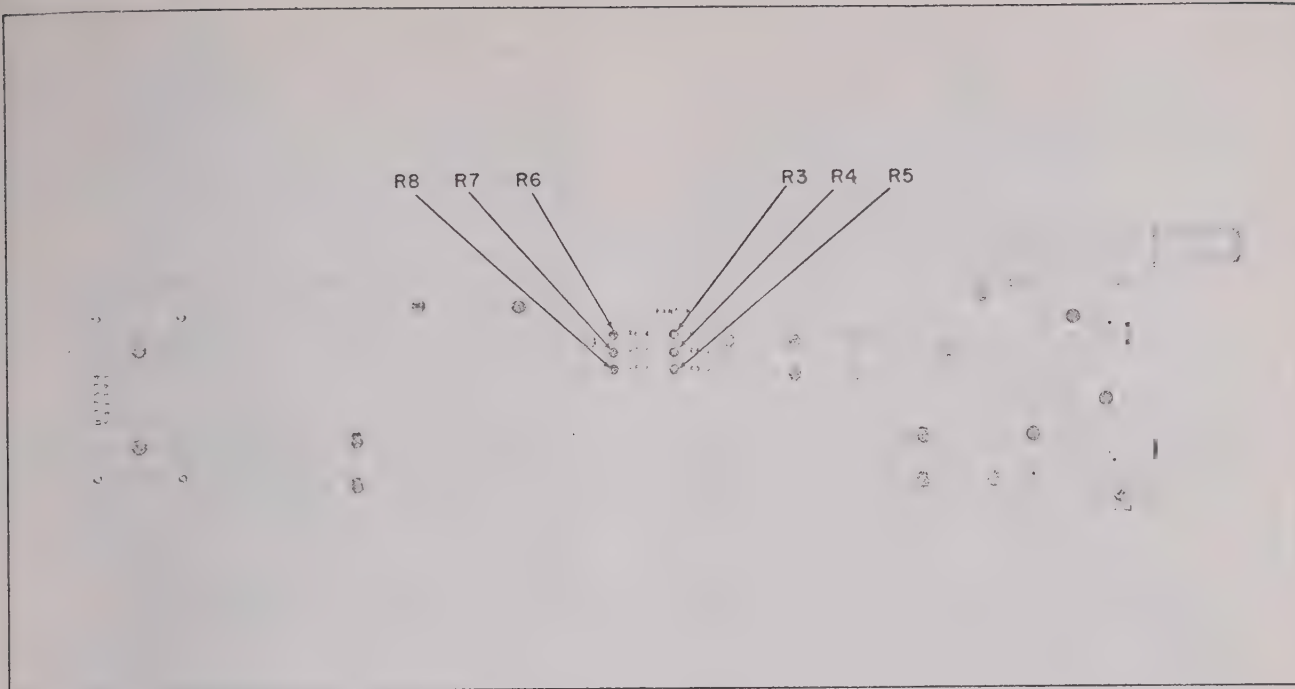


Figure 4-7. RF-100, Top View

4-11. SYSTEMATIC TROUBLE LOCALIZATION.

4-12. The systematic trouble localization techniques employed to maintain both the RF-100 and RF-100A are the same even though additional circuitry is used in the RF-100. Faults are localized down to the assembly board level; and, then, that assembly is replaced. It is not recommended that repairs on Triode Oscillator assembly A3 be attempted in the field; this assembly is best repaired at the factory. Primary sources of trouble are those assemblies which contain active elements, such as 160-MHz Preamplifier assemblies A2 and A5, and Level Amplifier assembly A6, along with the triode oscillator. In addition, when trouble shooting the RF-100, Buffer Amplifier and X8 Frequency Multiplier assembly A8 and 104.167-MHz Oscillator assembly A9 must be added to the list. The discernible symptom (or symptoms) associated with each of the above mentioned assembly boards is, in each instance; related to the characteristics and the availability of the 160 MHz intermediate frequency output at jack J10 for a given signal input. Before performing these procedures, check the sensitivity of the Main Frame. The procedures are as follows:

Note

Before performing any of the detailed procedures, disconnect power plug P2 (tuning head) from plug P3 (main frame), and check the availability of the proper power supply voltage on Plug P3 as follows:

P3-B	-12V
P3-C	+12V
P3-E	+300V
P3-F	+18V

Reconnect the power plug.

4-13. TUNING HEAD INOPERATIVE OVER 1-11 GHz BANDS.

- Connect a Hewlett-Packard 536A Frequency Meter to SIGNAL INPUT 11-40 GHz jack on the tuning unit. In series with the frequency meter, connect a Hewlett-Packard 423A detector and a Simpson Model 260 multimeter.
- Set SIGNAL FREQUENCY RANGE switch S1 to 26-40 GHz.
- Adjust the TUNING control to the highest signal frequency, and note the dial indication on the 1-3.5 GHz scale.
- Tune the frequency meter to 160 MHz above the noted scale frequency and observe a dip on the multimeter; if present, proceed to step f. If no indication occurs (no signal is present), proceed to step e.
- Connect a direct short across capacitor C1; and check the triode oscillator power output by connecting a 10-dB attenuator, a Hewlett-Packard Model 430C power meter, and a Model 477B

thermister mount to the triode oscillator output jack J1. If a 20 to 100 mw power output is not available, replace the triode oscillator in accordance with the procedure of paragraph 4-31. If the proper output is present with capacitor C1 shorted and not when the short is removed, troubleshoot level Amplifier A6 using the data of table 4-5.

f. Disconnect the miniature coaxial cable on the rear of the main frame, connected between the IF INPUT and IF OUTPUT jacks, and connect a signal generator, capable of generating a 160-MHz signal, to the IF INPUT jack.

g. Apply a 160-MHz signal to the IF INPUT jack and adjust the signal generator output level for -45 dBm and observe the display on the CRT screen.

h. Set SIGNAL FREQUENCY RANGE switch S1 to 0.94 - 3.5 GHz.

i. Disconnect the signal generator without touching the output level controls and reconnect the IF INPUT cable.

j. Disconnect plug P2 from relay K2, and connect the signal generator to jack J1.

k. Apply the same signal generator input used in step g and note that the indication on the main frame display is unchanged. If it changes, replace relay K2 in accordance with the procedures of paragraph 4-32.

l. Disconnect the signal generator without touching the signal generator output level control; reconnect plug P2 of relay K2.

m. Connect the signal generator to the SIGNAL INPUT 1-11 GHz jack and note a nominal 0 dB signal attenuation indicated on the main frame display. If it is present, proceed to the next step; if not, proceed to step o.

n. Disconnect plugs P1 and P2 from relay K1 and perform a continuity check using a dc meter between jacks J1 and J3.

o. Remove crystal from Mixer assembly A1 and check diode CR1, which is removed in accordance with the procedures of paragraph 4-24, with a microwave crystal test set. If the proper readings are not observed, replace the diode. If the proper readings are obtained, troubleshoot 160-MHz Preamplifier assembly A2 in accordance with the data of table 4-3.

4-14. TUNING HEAD INOPERATIVE OVER 11-40 GHZ BANDS ONLY.

a. Disconnect the miniature coaxial cable on the rear of the main frame, connected between the IF INPUT and IF OUTPUT jacks, and connect a signal generator capable of generating a 160-MHz signal to the IF INPUT jack.

b. Apply a 160-MHz signal to the IF INPUT jack and adjust the signal generator output level for -45 dBm and observe the display on the CRT screen.

c. Set SIGNAL FREQUENCY RANGE switch S1 to 11-18 GHz.

d. Disconnect the signal generator without touching the output level controls and reconnect the IF INPUT cable.

e. Disconnect plug P2 from relay K2, and connect the signal generator to jack J2.

f. Apply the same signal generator input used in step b and note that the indication on the main frame display is unchanged. If it changes, replace relay K2 in accordance with the procedures in paragraph 4-32.

g. Disconnect the signal generator without touching the signal generator output level controls, reconnect plug P2 of relay K2.

h. Connect the signal generator to the SIGNAL INPUT 11-40 GHz jack and note that the signal indication on the main frame display is increased by 6 dB. If it is not present, troubleshoot 160 MHz Preamplifier assembly A5 in accordance with the data of table 4-4. If the gain is not 6 dB, perform the alignment procedures of paragraph 4-22. If the signal indication is proper, perform step i.

i. Disconnect plugs P1 and P2 from relay K1 and perform a continuity check using a dc meter between jacks J2 and J3.

4-15. RF-100 INOPERATIVE OVER .01-1 GHZ BAND ONLY. When no signal pip is present, proceed as follows:

a. Disconnect plug P2 from 2.5-GHz bandpass filter FL3 and connect a 10-dB attenuator and a Hewlett-Packard Power Meter, Model 430C, and Thermistor Mount Model 477B to jack J1 of the filter assembly.

b. Observe that a 3 mw power level is available at the 2.5-GHz bandpass filter output jack.

Note

The indicated power level must be increased by 10 dB, the size of the inserted pad, to obtain the power level available at the output jack.

If the proper power level is present, the fault must be in the mixer, isolator, or 2.5-GHz trap FL1; proceed to step c. If it is not, the fault must be either in Oscillator assembly A9 or Buffer Amplifier and X8 Frequency Multiplier assembly A8; then proceed to step d.

Section IV Maintenance

c. To troubleshoot the mixer assembly, loosen coupler CP3 on Mixer assembly A7 and check diode CR1, which can be removed in accordance with the procedures of paragraph 4-30, with a microwave crystal test set. If the proper readings are not obtained, replace the diode. If the diode is good, reinsert the diode, secure the screw cap, and refer to the alignment procedures covering 2.5-GHz trap FL1.

d. To troubleshoot the oscillator assembly, disconnect plug P2 from jack J1 of Oscillator assembly A9 and connect a 10-dB pad, and a Hewlett-Packard 430C Power Meter using a HP 477B Thermistor Mount to jack J1. Observe that the output power is approximately 20 mw. If it is not, perform the alignment procedures of paragraph 4-23. If the proper power indication is available, troubleshoot Buffer Amplifier and X8 Frequency Multiplier assembly A8 in accordance with the data of table 4-6.

4-16. When the zero pip of the RF-100, using the .01-1 GHz range, "breaks up" proceed as follows:

Note

The "breaking up" of the zero pip results in the appearance of several pips which assume the position of sidelobes - similar to squeeging.

- a. Tune the SIGNAL FREQUENCY TUNING dial to 0.
- b. Tune X8 Frequency Multiplier Assembly A8 and 2.5-GHz preselector in accordance with the procedures of paragraphs 4-24 and 4-25.

4-17. SENSITIVITY REQUIREMENTS OF A PARTICULAR BAND CANNOT BE MET.

- a. Set SIGNAL FREQUENCY RANGE switch S1 to the desired band.
- b. Connect the clip-on current probe of Hewlett-Packard Model 428B clip on milliammeter to the white/orange lead of 160-MHz Preamplifier A2 for all bands below 11 GHz or to the white/yellow lead of 160-MHz Preamplifier A5 for all bands above 11 GHz.
- c. Check that a current, consistent with the following data, is available; if the proper current is not available, check the resistors as shown.

Range	Milliamps	Check Resistors
0.01-1	0.5	R3 & R11
0.94-3.5	1.2	R4 & R9
3.2-11	3	R5 & R10
11-18	4	R6 & R10
18-26	3	R7 & R10
26-40	3	R8 & R10

4-18. ALIGNMENT AND ADJUSTMENT PROCEDURES.

4-19. Paragraphs 4-20 through 4-26 contain the alignment and adjustment procedures for the RF-100. Because the circuits of the RF-100 are the same as those provided in the RF-100A, except that the RF-100 contains additional circuitry, these procedures are applicable to the RF-100A, also. It is assumed that the proper operating potentials are available from main frame.

4-20. CALIBRATING THE SIGNAL FREQUENCY DIAL. To calibrate the SIGNAL FREQUENCY dial with the output frequency of the triode local oscillator, proceed as follows:

- a. With the tuning unit withdrawn from the MF-100, connect the power cables between the main frame and the tuning unit.
- b. Set SIGNAL FREQUENCY RANGE switch S1 to the 11-18 GHz position.
- c. Connect a Hewlett-Packard 536A Frequency Meter to the SIGNAL INPUT 11-40 GHz jack on the tuning unit. In series with the frequency meter, connect a Hewlett-Packard 423A detector and a Simpson Model 260 Multimeter.
- d. Apply power to the MF-100.
- e. Adjust the SIGNAL FREQUENCY TUNING control to obtain an indication of 3.5 on the .94-3.5 GHz scale.
- f. Check the local oscillator output frequency by tuning the frequency meter for a dip on the multimeter; then set the frequency meter to 3.66 GHz and tune the SIGNAL FREQUENCY TUNING control for a similar multimeter dip.
- g. Loosen the set screws fastening the gear to the local oscillator drive shaft without moving the shaft (changing the frequency) and set SIGNAL FREQUENCY TUNING control until the dial scale is set for 3.5 GHz.
- h. Tighten the drive shaft gear set screws.

4-21. ALIGNMENT OF PREAMPLIFIER ASSEMBLY A5.

- a. Connect the test equipment as shown in figure 4-8.
- b. Set SIGNAL FREQUENCY RANGE switch to 11-26 GHz. Remove Attenuator Assembly AT3 (6 dB pad) from Frequency Selective T assembly A4. Then, terminate the unused connector of the T with a termination.
- c. Alternately, tune capacitor A5C2 and transformer AST1 to obtain a flat output from 110 to 210

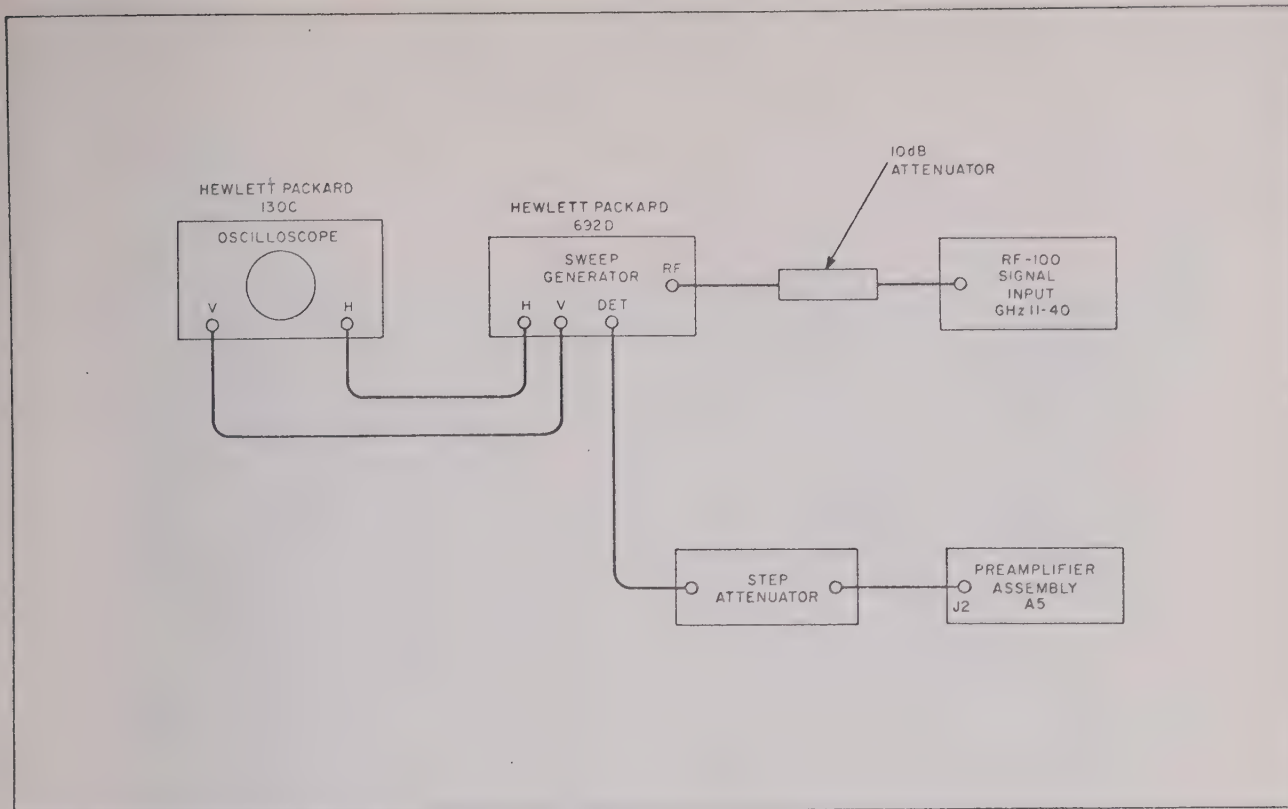


Figure 4-8. Test Setup for Alignment of 160-MHz Preamplifier Assembly A5

MHz (less than 1.5 dB). The gain should be 7 dB minimum, without overdriving the stage to the point where limiting occurs.

- d. Remove termination and replace 6 dB pad.

4-22. ALIGNMENT OF PREAMPLIFIER ASSEMBLY A2. Use the test setup of figure 4-8 except that SIGNAL INPUT GHZ 1-11 jack is used and 160-MHz preamplifier assembly A2 replaces assembly A5 in the figure.

- a. Set SIGNAL FREQUENCY RANGE switch S1 to 0.94-3.5 GHz.

- b. Alternately tune capacitor A2C3 and transformers A2T1 and A2T2 for a flat response from 110 to 210 MHz (less than 1.5 dB). The gain should be 0 dB minimum, without overdriving the stage to the point where limiting occurs.

4-23. ALIGNMENT OF OSCILLATOR-TRIPLER ASSEMBLY A9.

- a. Connect the test equipment as shown in figure 4-9.

- b. Set the power meter range switch to 10 mw, resistance to 200, and the polarity negative.

- c. Set the spectrum analyzer controls as follows:

Dispersion	1 MHz/DIV
Freq Range	.01 - 1 GHz
Amplitude Scale	Log

- d. Connect a miniature 50 ohms coaxial cable between A9A1TP1 and the sampler.

- e. Apply power to the oscillator assembly.

- f. Adjust capacitor A9A1C4 to obtain maximum amplitude of the pip at 104 MHz on the analyzer screen.

- g. Adjust capacitor A9A1C9 to obtain a maximum indication on the power meter.

- h. Adjust transformer A9A1T2 to obtain a maximum indication on the power meter. The minimum indication should be 70 milliwatts.

- i. Turn the power to the oscillator off, then on again. Check that the pip height on the analyzer and the power indication on the power meter does not change. If they do, readjust capacitor A9A1C9 for a maximum indication. Then turn off and on again. If the power indication changes, repeat steps f through i.

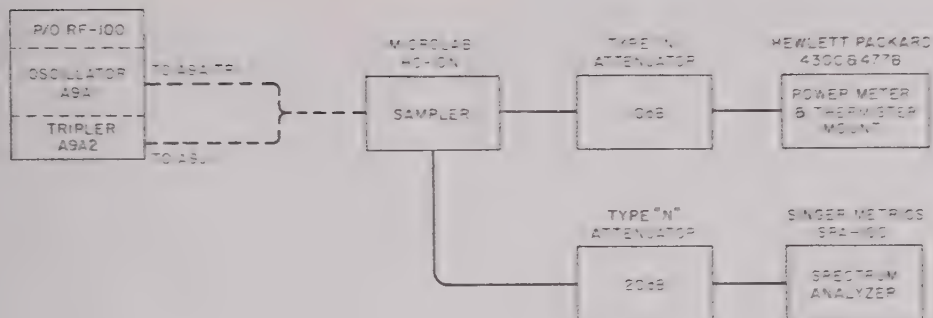


Figure 4-9. Test Setup for Alignment of Oscillator-Tripler Assembly A9

j. Remove power and disconnect the miniature coaxial cable from between the oscillator and sampler, and connect a TNC to BNC cable between the tripler section of assembly A9 and the sampler.

k. Apply power to the oscillator assembly.

l. Set the analyzer to 104 MHz and tune inductor A9A2L4 for a null at 104 MHz. Inductor A9A2L4 should be set to mid range between the two points where the pip reappears on the screen.

m. Set the spectrum analyzer to 208 MHz and tune inductor A9A2L5 for a null at 208 MHz.

n. Set the spectrum analyzer to 312 MHz and tune capacitor A9A2C1 for maximum power on power meter. No secondary pips should appear on analyzer display.

o. Adjust transformer A9A1T2 and capacitor A9A1C9 for maximum power level (note this power level; 20 mw minimum).

p. Turn the power to the oscillator off then on again; the power level should not change. If it does, readjust capacitor A9A1C4 for a maximum power level indication.

q. Readjust capacitor A9A2C1 for a maximum power level indication without the presence of a secondary pip at the signal base.

r. Adjust transformer A9A1T2 and capacitor A9A1C9 for an indication without the presence of a secondary pip at the signal base.

s. Turn the power to the oscillator off and on; the amplitude of the pip displayed on the signal analyzer should not change from the mw power indication noted in step o.

4-24. ALIGNMENT OF 2.5-GHz BUFFER AMPLIFIER AND X8 FREQUENCY MULTIPLIER A8.

a. Connect the equipment as shown in figure 4-10.

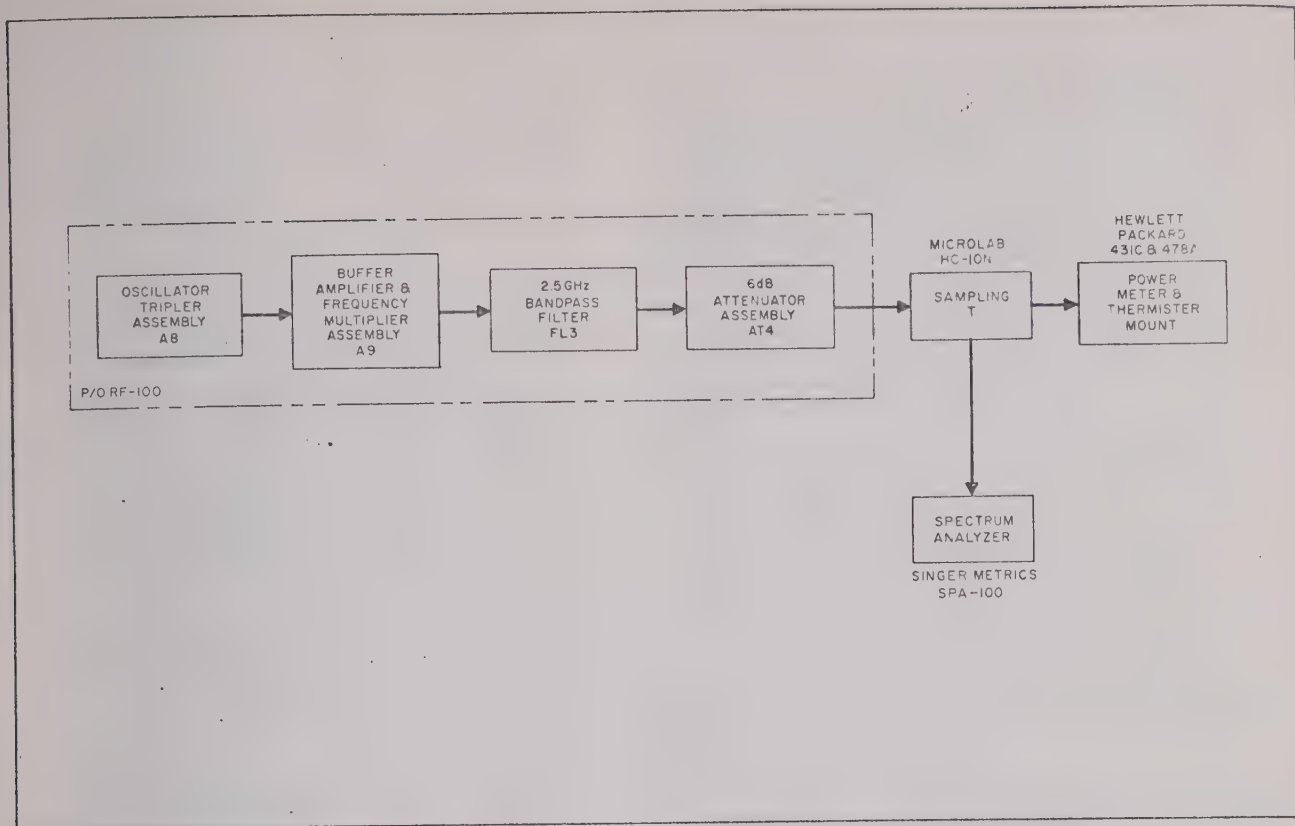


Figure 4-10. Test Setup for Alignment of 2.5-GHz Buffer Amplifier and X8 Frequency Multiplier Assembly A8

b. On the spectrum analyzer, set the following controls:

Dispersion	3 MHz/DIV
Amplitude Scale	Log
IF Bandwidth	Max

c. Set the power meter to the 3 mw range.

d. Turn the cavity trimmer screw of assembly A8 for maximum power.

e. Adjust trimmer capacitor C5 for a maximum power indication (0.9 mw, min).

f. Detune each tuning screw on three-cavity filter FL3 in both directions for a 3-dB variation from resonance. If the signal breaks up because of detuning retune the cavity trimmer screw. Repeat the signal to the power indication of step e after each tuning screw is detuned.

g. Turn off tuning head power; and, after a few minutes reapply power. Check that the response display is unchanged. If it has changed, perform step h.

h. When the proper power requirements cannot be met (0.9 mw) and sustained when power is turned off and on, loosen the 6-32 set screws that hold the

body in place in the cavity of assembly A8, and slide the body in or out of the cavity to obtain a maximum power indication at 2.5 GHz. Then repeat steps e through g.

4-25. ALIGNMENT OF 2.5-GHz TRAP ASSEMBLY FL1 and FL3.

a. Connect a signal generator, capable of providing a 10-MHz output, to the SIGNAL INPUT 0.01 GHz input jack; set the signal generator output frequency to 10 MHz.

b. Set the FREQ DISPERSION switch to 10 MHz/DIV.

c. Adjust the SIGNAL FREQ POSITION control to center the zero pip screen; note that the zero pip is bordered by the + and - 10 MHz pips.

d. Adjust the trap tuning capacitors for a minimum zero pip while not permitting any decrease in the +10 MHz pip amplitude.

4-26. ALIGNMENT OF AMPLIFIER ASSEMBLY A6 INPUT CURRENT NETWORK.

a. With the SIGNAL FREQUENCY RANGE switch set to .94 - 3.5 GHz, connect the clip-on current probe of a Hewlett-Packard Model 428B clip-on

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milliammeter to the white/orange lead of 160-MHz Amplifier assembly A2.

b. Terminate SIGNAL INPUT .01 - 1 GHz and .94 - 3.5 GHz input jacks with a 10-dB pad and tune through the entire frequency range, find the maximum current indication and set the SIGNAL TUNING control to that frequency.

Note

Steps c and d are to be performed only on the RF-100. The remaining steps apply to both RF-100 and RF-100A.

c. Set SIGNAL FREQUENCY RANGE switch to 0.01 - 1 GHz.

d. Adjust Band 1 potentiometer R3 for a current indication of 0.5 milliamperes.

e. Set SIGNAL FREQUENCY RANGE switch to 0.94 - 3.5 GHz.

f. Adjust Band 2 potentiometer R4 for a current indication of 1.2 milliamperes.

g. Set SIGNAL FREQUENCY RANGE switch to 3.2 - 11 GHz.

h. Adjust Band 3 potentiometer R5 for a current indication of 3 milliamperes.

i. Terminate the SIGNAL INPUT 11 - 40 GHz input jack with an external mixer and set SIGNAL FREQUENCY RANGE switch to 11 - 18 GHz.

j. Connect the clip-on current probe of Hewlett-Packard Model 428B clip-on milliammeter to the white/yellow lead of 160 MHz amplifier assembly A5.

k. Adjust Band 4 potentiometer R6 for a current indication of 4 milliamperes.

l. Set SIGNAL FREQUENCY RANGE switch to 18 - 26 GHz.

m. Adjust Band 5 potentiometer R7 for a current indication of 3 milliamperes.

n. Set SIGNAL FREQUENCY RANGE switch to 26 - 40 GHz.

o. Adjust Band 6 potentiometer R8 for a current indication of 3 milliamperes.

4-27. PARTS REMOVAL AND REPLACEMENT.

4-28. GENERAL. The replacement of parts within the tuning head is accomplished after the tuning head is removed from the Main Frame. Some of the assemblies in the tuning head are not repairable in the field. These include triode oscillator V1, the tuning dial drive assembly, the band pass filter FL3 and the X8 multiplier of buffer amplifier and X8 frequency multiplier assembly. These assemblies, when careful tests have indicated the need for their

repair, should be returned to The Singer Company. They should not be opened for inspection or cleaning or any other reason, but should be removed from the tuning head in strict accordance with the procedures given herein. Parts that are mounted on printed circuit boards can be replaced after the boards have been removed (paragraphs 4-34, 4-35 and 4-36). To remove a part, use a soldering iron with a low power rating (40 watts maximum) and a solder sucker to remove the solder. Because the leads from a part have been crimped during manufacture, it is also necessary to clip the ends of the leads in order to remove the part. After a part has been replaced, check the alignment of the assembly affected by the replacement; after realignment, check the performance standards.

4-29. TUNING HEAD. To remove the tuning head, follow the procedure outlined below:

a. Remove the top and bottom dust covers of the main frame (refer to the Main Frame manual).

b. Remove the five screws that hold the top plate of the tuning head to the frame of the Main Frame.

c. Remove the four screws that hold the front panel of the tuning head to the front panel of the Main Frame.

d. When removing the RF-100, disconnect the input and output cables from the up converter assembly. These are the cables connected to port 1 on the circulator and the lowest cable on the front of the up converter assembly.

e. Pull the tuning head out of the Main Frame far enough (approximately 4 inches) to gain access to the IF output connector, which is the gold-plated connector attached to coaxial relay K2.

f. Disconnect the IF output connector from coaxial relay K2.

g. Disconnect power connector P2 of the tuning head from mating connector P3 of the Main Frame.

h. Complete the withdrawal of the tuning head from the Main Frame.

4-30. MIXER CRYSTALS. To remove the crystal diodes from the .01-1 GHz mixer, perform steps a and b; to remove the crystal from the 1-11 GHz mixer, perform steps c through f; and to remove the crystal from the accessory mixers, perform steps g through i.

a. To replace the crystal in the 0.01-1 GHz mixer, unscrew W4P1 from coupler CP3. Unscrew coupler CP3 from mixer A7 and, grasping the special holder attached to the exposed contact of the diode, remove the defective diode with its insulating ring.

b. Place the insulating ring and holder over the anode end of the replacement diode (Microwave Assoc. MA417) and insert into the mixer. Replace CP3 and connect W4P1 to CP3.

c. To replace the crystal in the 1-11 GHz mixer, remove the two screws that secure 160-MHz preamplifier A2 to its mounting strip.

d. Unscrew A2J1 from mixer A1.

e. Withdraw the defective diode and insert a replacement 1N1132.

f. Perform steps e through c in reverse.

g. To replace the crystal in a Model K_u-100, K-100 or K_a-100 Waveguide Mixer, unscrew the knurled body from the waveguide.

h. Remove the defective diode and insert a replacement crystal, as required.

Mixer	Diode Type
K _u -100	1N4605
K-100	1N26
K _a -100	1N53

i. Screw the knurled body to the waveguide. After the crystal has been replaced, check the mixer for sensitivity. If the sensitivity specification cannot be met, it will be necessary to rotate the crystal in its seat. This procedure may have to be repeated several times until proper sensitivity is attained.

4-31. TRIODE OSCILLATOR. Do not attempt repairs on this assembly. The assembly must be removed in accordance with the instructions given below and then shipped to The Singer Company for repair.

a. Remove the four screws that hold the triode oscillator assembly to the top plate of the tuning head.

b. Pull the triode oscillator assembly slightly away from the top plate to gain access to the three soldered connections. Unsolder the plate connection near the front-panel end of the assembly and the two filament connections at the rear of the assembly.

c. Loosen the two setscrews in the gear on the shaft of the assembly and remove and retain the gear for use with the replacement assembly.

4-32. COAXIAL RELAYS. Either coaxial relay can be removed by following the procedure given below:

a. Disconnect the three coaxial cables from the relay.

b. Remove the two screws that hold the relay to the top plate of the tuning head.

c. Unsolder the leads to the coil of the relay, and

remove the relay.

4-33. REGULATOR ASSEMBLY. To gain access to any of the parts of the regulator assembly (the six bias adjustments and the two zener regulators for the triode oscillator), follow the procedures given below:

a. In the RF-100, remove the input and output cables to the 2.5-GHz bandpass filter.

b. Remove the two screws and lockwashers that secure the regulator assembly to the top plate of the tuning head.

4-34. LEVEL AMPLIFIER. To remove the level amplifier printed circuit board, remove the two screws that hold the mounting brackets to the casting, and raise up the printed circuit board.

4-35. 160 MHz PREAMPLIFIERS. To gain access to the parts within the 160 MHz preamplifiers, follow the procedure given below:

a. Remove the two screws that secure the preamplifier to the strap that joins both preamplifiers.

b. Disconnect the preamplifier associated with the 11-40 GHz input from its associated mixer. Move this preamplifier as far away from the other preamplifier as its wired connections permit.

c. Remove both side plates of the preamplifier requiring repairs by removing the four screws that secure each plate to the preamplifier body. The parts on the printed circuit board are now accessible.

4-36. OSCILLATOR-TRIPLER ASSEMBLY. To gain access to the parts on the printed circuit boards of the oscillator-tripler assembly, follow the procedure below:

a. Remove the four bolts that secure the top plate of the assembly to the bottom plate, and remove the top plate.

b. Rotate the body of the oscillator-tripler assembly to expose the wiring at the bottom of the assembly.

c. Unsolder the wiring to the feed-thru capacitors and connector, but do not remove these components.

d. Remove the four screws and lockwashers that hold the mounting brackets to the oscillator-tripler assembly body.

e. Remove the printed circuit boards and the mounting brackets through the top of the assembly.

f. Unscrew the board on which the part to be replaced is mounted from the mounting brackets.

g. Unsolder the -12 volt and +12 volt leads from the board to be removed; do not unsolder the coaxial connection between the two boards.

h. Separate the two boards by rotating them

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about the coaxial connection only to the extent needed to gain access to the soldering connection.

Note

During reassembly, it might be necessary to remove the solder from the +12 and -12 volt connection holes so that the wires easily slip into the holes when the boards are rotated back into the original position.

4-37. 2.5-GHz BANDPASS FILTER. To remove the 2.5-GHz bandpass filter, follow the procedure below:

- a. Remove the regulator assembly from the top plate of the tuning head (paragraph 4-33).
- b. Remove the four screws from the bottom of the regulator assembly that hold the 2.5-GHz band-

pass filter, and remove the filter.

4-38. X8 MULTIPLIER. To remove the X8 multiplier, remove the input and output coaxial connectors, and remove the three screws that secure it to the top plate of the tuning head.

4-39. VOLTAGE MEASUREMENTS.

4-40. To facilitate troubleshooting and repair of the circuit assemblies, tables 4-3 through 4-8 provide nominal emitter, base, and collector voltage levels that should be available for the referenced transistor. Each table provides the data associated with a particular circuit assembly board. If an assembly is not referenced it is because no transistors are located on that board. Note that all voltages are measured with respect to ground using a vtvm.

TABLE 4-3. VOLTAGE MEASUREMENTS, 160-MHz PREAMPLIFIER A2

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	Fairchild FT-45	-10.5	-10	0

Note: SIGNAL FREQUENCY RANGE switch set to 1-3.5 GHz.

TABLE 4-4. VOLTAGE MEASUREMENTS, 160-MHz PREAMPLIFIER A5

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	Fairchild FT-45	-10.5	-10	0

Note: SIGNAL FREQUENCY RANGE switch set to 11-18 GHz.

TABLE 4-5. VOLTAGE MEASUREMENTS, LEVEL AMPLIFIER A6

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3440	+0.8	-1.5	50
Q2	2N3694	-0.6	-0.1	+1.5
Q3	2N3694	-0.6	-0.1	+12

TABLE 4-6. VOLTAGE MEASUREMENTS, BUFFER AMPLIFIER AND X8 FREQUENCY MULTIPLIER A8

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N4427	-0.5	0	+12

TABLE 4-7. VOLTAGE MEASUREMENTS. 104.107-MHz OSCILLATOR A9

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
A1Q1	2N3863	-0.5	0	-5
A1Q2	2N3842	-0.5	0	-12
A2Q1	2N3846	-12	-12	+12

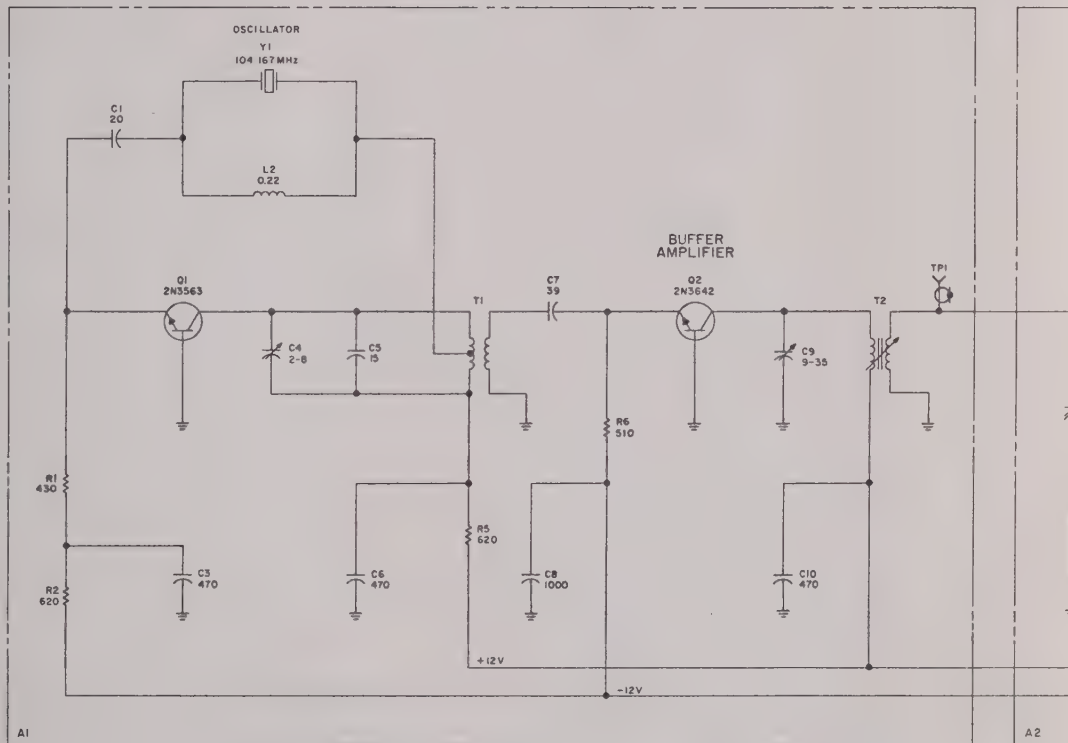
SECTION V

SCHEMATIC DIAGRAMS

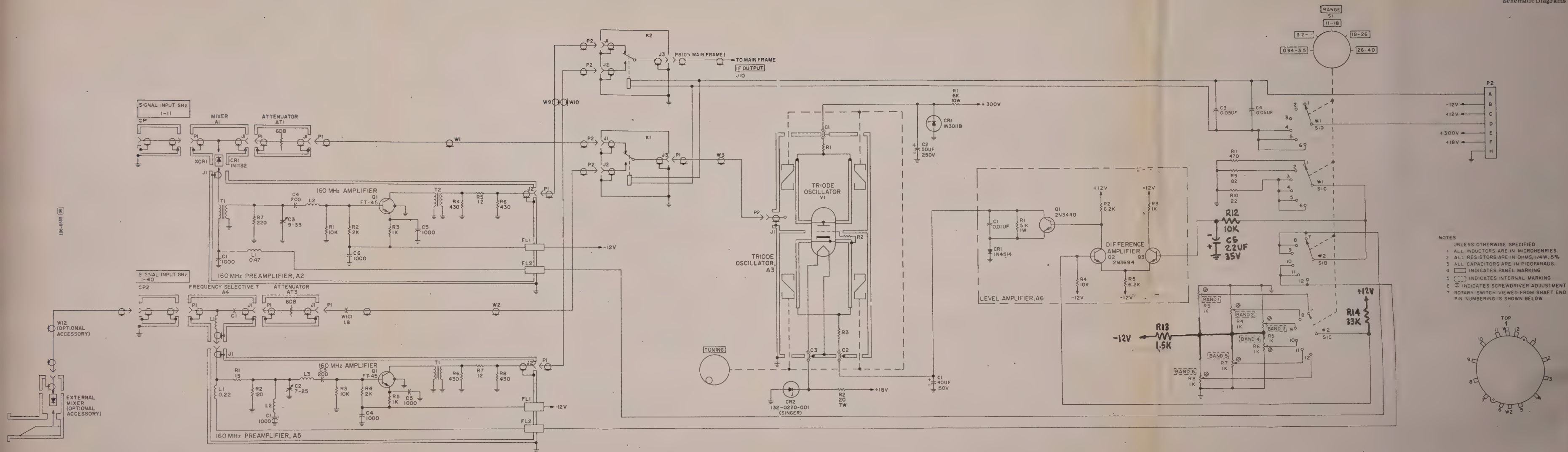


Figure 5-1. Model RF-100 Tuning Head Schematic Diagram

100-4537



NOTES UNLESS OTHERWISE SPECIFIED:
 1 ALL RESISTORS ARE IN OHMS, 1/4W, 5%
 2 ALL CAPACITORS ARE IN PICOFARADS
 3 ALL INDUCTORS ARE IN MICROHENRIES



SECTION VI PARTS LIST

6-1. INTRODUCTION

6-2. This parts list section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alpha-numerically by reference symbol and include all replaceable items such as electronic, electro-mechanical, and mechanical parts of the equipment. In some cases, values, ratings and manufacturer sources shown are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part(s) removed from the equipment.

6-3. ORDERING INFORMATION

6-4. The following instructions will aid in ordering parts from the Parts Lists, tables 6-2 through 6-4.

- a. Address all inquiries or orders to:

CUSTOMER SERVICE
Department 50
The Singer Company
Metrics Division
915 Pembroke Street
Bridgeport, Connecticut, 06608

- b. Include the following information:

- 1) Model and Serial Number of instrument.
- 2) Singer Part Number.
- 3) Reference Symbol Number.
- 4) Description (as shown on list).

6-5. HOW TO USE THE PARTS LIST

6-6. Paragraphs 6-7 through 6-11 describe the use and meaning of the five columns included in the parts list (see figure 6-1).

6-7. REF SYMBOL COLUMN. The Ref Symbol Column (1, figure 6-1) contains an alpha-numerical listing of parts as they appear on equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument.

6-8. DESCRIPTION COLUMN. The Description Column (2, figure 6-1) contains the identification of component parts including all pertinent specifications and Singer part number. When the description column is used for a part which is identical to a part which has already been described; SAME AS (3) is used along with the reference symbol of the previously used part. In these instances, columns 3, 4, 5 are left blank. When the description column is used for a reference symbol for which no part exists; NOT USED (4) is placed in the column. In these instances, columns 3, 4, 5, are left blank.

6-9. MANUFACTURER'S PART NUMBER COLUMN. The Manufacturer's Part Number column (5, figure 6-1) contains the part number as designated by the manufacturer of the part.

6-10. MFR'S CODE COLUMN. The Mfr's Code column (6, figure 6-1) references the manufacturer by an assigned code number as listed in Federal Supply Code Handbook H4-2. For manufacturers not listed in H4-2, a letter code will be assigned. Table 6-1 includes the manufacturer and his code designation.

6-11. MAINT QTY COLUMN. The Maint Qty column (7, figure 6-1) contains the number of additional components recommended to keep the equipment at an optimum performance level. The recommended number of components in the Maint Qty column is based on 2000 hours of equipment operation.

TABLE 6-2. PARTS LIST					SECTION VI PARTS LIST	
REF SYMBOL	DESCRIPTION	MANUFACTURER'S PART NUMBER	MFR'S CODE	MAINT QTY		
C109	CAPACITOR, ELECTROLYTIC. 20uf, MINUS 10PCT, PLUS 75PCT, 600V SINGER PART NO. 150-5004-001	D40690	56289	2		
C110 THRU C124	SAME AS C109					
C125	NOT USED					
DS1	LAMP, INCANDESCENT SINGER PART NO. 160-6001-004	327	08806	2		
R1 THRU R14	RESISTOR, FIXED COMP., 750 ohms. PORM 5PCT, 1/2W SINGER PART NO. 151-1003-751J	EB7515	01121	1		

Figure 6-1. Parts List Sample

TABLE 6-1. MANUFACTURER'S CODE

Number	Name	Number	Name
INSTD	Industry Standard	63743	Ward Leonard Electric Co. Mount Vernon, N.Y.
01121	Allen-Bradley Co. Milwaukee, Wis.	71590	Centralab Division of Globe-Union Inc. Milwaukee, Wis.
01295	Texas Instruments, Inc. Dallas, Texas	72136	Electro-Motive Mfg. Co., Inc. Willimantic, Conn.
02660	Amphenol-Borg Electronics Corp. Maywood, Ill.	72982	Erie Technological Products Inc. Erie, Pa.
02735	Radio Corp. of America Solid State and Receiving Tube Division Somerville, N.J.	74970	E. F. Johnson Co., Waseca, Minn.
04713	Motorola Inc. Semiconductor Products Division Phoenix, Arizona	78488	Stackpole Carbon Co., St. Marys, Pa.
07263	Fairchild Camera and Instrument Corp. Semiconductor Division Mountain View, Calif.	78526	Stanwyck Winding Co., Inc. Newburgh, N.Y.
16665	The Singer Company Metrics Division Bridgeport, Conn.	79089	Radio Corp. of America Solid State and Receiving Tube Division Harrison, N.J.
28480	Hewlett-Packard Co. Palo Alto, Calif.	81349	Military Specifications
56289	Sprague Electric Co. North Adams, Mass.	91637	Dale Electronics, Inc., Columbus, Nebr.
		91737	Gremar Electronics, Inc., Wakefield, Mass.
		96341	Microwave Associates Burlington, Mass.
		98291	Sealectro Corp., Mamaroneck, N.Y.
		74868	AMPHENOL CORP. AMPHENOL RF. DIVISION DANBURY, CONN.

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Manuf Qty
AT1	ATTENUATOR, 6 DB	134-0022-001	16665	1
AT1J1	CONNECTOR, JACK, NON-REPLACEABLE PART OF AT1			
AT1P1	CONNECTOR, PLUG, NON-REPLACEABLE PART OF AT1			
AT2	ISOLATOR	556146662	16665	1
AT2J1 AND J2	CONNECTOR, JACK, NON-REPLACEABLE PART OF AT2			
AT3 AND AT4	SAME AS AT1			
AT3J1	CONNECTOR, JACK, NON-REPLACEABLE PART OF AT3			
AT3P1	CONNECTOR, PLUG, NON-REPLACEABLE PART OF AT3			
AT4J1	CONNECTOR, JACK, NON-REPLACEABLE PART OF AT4			
AT4P1	CONNECTOR, PLUG, NON-REPLACEABLE PART OF AT4			
CP1 AND CP2	MIXER ADAPTER ASSY	556146-969	16665	1
CP3	MIXER ADAPTER ASSY	103-1633-001	16665	1
CP3J1	CONNECTOR, JACK, NON-REPLACEABLE PART OF CP3			
CP4	SAME AS CP1			
CP5	ADAPTER, RIGHT ANGLE SINGER PART NO. 556146-995	6017	91737	1
CR1	SEMICONDUCTOR DEVICE, DIODE SINGER PART NO. 556118-140	1N3011	04713	1
CR2	SEMICONDUCTOR DEVICE, DIODE	132-0220-001	16665	1
C1	CAPACITOR, FIXED, ELECTROLYTIC, 40 UF, 150VDC SINGER PART NO. 556147-228	390406F150EL4	56289	1
C2	CAPACITOR, FIXED, ELECTROLYTIC 50UF, 250V SINGER PART NO. 556147-210	390506F250JE4	56289	1
FL1	205 GHz TRAP ASSY	103-1581-001	16665	1
FL1J1 AND J2	CONNECTOR, JACK, NON-REPLACEABLE PART OF FL1			
FL2	FILTER, BANDPASS	556146-663	16665	1
FL2J1 AND J2	CONNECTOR, JACK, NON-REPLACEABLE PART OF FL2			
FL3	FILTER, BANDPASS	103-1579-001	16665	1
FL3J1 AND J2	CONNECTOR, JACK, NON-REPLACEABLE PART OF FL3			
FL3R1	RESISTOR, NON-REPLACEABLE PART OF FL3			
J1	CONNECTOR, JACK SINGER PART NO. 556146-233	6030	91737	1
K1	RELAY, COAXIAL SINGER PART NO. 556146-903	360-11892-48	02660	1

Section VI
Parts List

TABLE 6-2. PARTS LIST

Ref	Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
K1J1 J3	THRU	CONNECTOR, JACK, NON-REPLACEABLE PART OF K1			
K2		RELAY, COAXIAL SINGER PART NO. 556146-907	315-10049-8	02660	1
K2J1 J3	THRU	CONNECTOR, JACK, NON-REPLACEABLE PART OF K2			
L2		INDUCTOR	132-0321-001	16665	
P1		CONNECTOR, PLUG SINGER PART NO. 168-4038-001	6001/NONTARN	91737	1
P2		CONNECTOR, PLUG, 7 PIN, W/HOOD AND CLAMP SINGER PART NO. 556016-061	126-195	02660	1
R1		RESISTOR FIXED, WIRE-WOUND, 6.0K OHMS, PORM 5 PCT, 10W SINGER PART NO. 161-2003-602J	10XM6000	63743	1
R2		RESISTOR FIXED, WIRE-WOUND, 20 OHMS, PORM 5 PCT, 7W SINGER PART NO. 556146-936	244E2005	56289	1
R3 R8	THRU	RESISTOR, VARIABLE, 1K OHM, PORM 10 PCT, 1/2W SINGER PART NO. 556204-203	2389-1K	91637	1
R9		RESISTOR FIXED, COMP., 82 OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-820J	CB8205	01121	1
R10		RESISTOR FIXED, COMP., 22 OHMS, PORM 5 PCT 1/4W SINGER PART NO. 151-1002-220J	CB2205	01121	1
R11		RESSITOR, FIXED, COMP., 470 OHMS PORM 5PCT SINGER PART NO. 151-1002-471J	CB4715	01121	1
S1		SWITCH, ROTARY, 6 POS.	133-0091-001	16665	1
w1		CABLE ASSY	102-9200-400	16665	1
w1C1		CAPACITOR, FIXED, COMP., 1.8PF PORM 10PCT 500V SINGER PART NO. 150-4001-1R8K	GA1.8PF PORM 10PCT	78488	1
w1P1		CONNECTOR, PLUG	149-0177-001	16665	1
w1P2		CONNECTOR, PLUG SINGER PART NO. 168-4038-001	6001	91737	1
w2		CABLE ASSY	102-9200-300	16665	1
w2P1		CONNECTOR, PLUG SINGER PART NO. 556146-974	6039	91737	1
w2P2		SAME AS w1P2			
w3		CABLE ASSY	102-9112-004	16665	1
w3P1 P2	AND	SAME AS w1P2			
w4		CABLE ASSY	102-9200-304	16665	1
w4P1 P2	AND	SAME AS w2P1			
w5		CABLE ASSY	102-9112-002	16665	1
w5P1 P2	AND	SAME AS w1P2			
w6		SAME AS w5			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Main Qty
W6P1 AND P2	SAME AS W1P2			
W7	CABLE ASSY	102-9200-302	16665	1
W7P1	SAME AS W2P1			
W7P2	SAME AS W1P2			
W8	CABLE ASSY	102-9200-303	16665	1
W8P1	SAME AS W2P1			
W8P2	SAME AS W1P2			
W9	CABLE ASSY	102-9112-003	16665	1
W9P1 AND P2	SAME AS W1P2			
W10	SAME AS W9			
W10P1 AND P2	SAME AS W1P2			
W11	SAME AS W5			
W11P1 AND P2	SAME AS W1P2			
A1	MIXER ASSY	134-0018-001	16665	1
A1CR1	SEMICONDUCTOR DEVICE, DIODE SINGER PART NO. 556146-342	1N1132	81349	1
A1J1	CONNECTOR, JACK, NON-REPLACEABLE PART OF A1			
A1P1	CONNECTOR, PLUG, NON-REPLACEABLE PART OF A1			
A2	160 MHZ PREAMPLIFIER ASSY	103-1593-001	16665	1
A2C1	CAPACITOR, FIXED, CERAMIC DISC, 0.001 UF, PORM 5 PCT, 1000V SINGER PART NO. 556060-046	DD-102	71590	2
A2C2	CAPACITOR, FIXED, DIPPED MICA, 20 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-200EJO	DM15E200J0500WV4CR	72136	1
A2C3	CAPACITOR, VARIABLE, CERAMIC 9T035PF SINGER PART NO. 150-0008-008	538-011D9-35	72982	
A8C3	SAME AS A8C1			
A2C4	CAPACITOR, FIXED, CERAMIC DISC, 200PF, 1000V SINGER PART NO. 556146-696	DD201	71590	1
A2C5 AND C6	SAME AS A2C1			
A2FL1 AND FL2	FILTER, FEED-THRU SINGER PART NO. 556146-774	1270-016	72892	1
A2J1	CONNECTOR, JACK	103-1619-001	16665	1
A2J2	CONNECTOR, JACK SINGER PART NO. 556146-629	6014	91737	1
A2L1	INDUCTOR, SHIELDED, 0.47 SINGER PART NO. 556200-002	DINK 0.47	78526	1

TABLE 6-2. PARTS LIST

Ref	Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2L2		INDUCTOR	132-0321-001	16665	1
A2Q1		TRANSISTOR SINGER PART NO. 556146-739	FT45	07263	1
A2R1		RESISTOR FIXED,COMP., 10K OHMS,PORM 5 PCT, 1/4 W SINGER PART NO. 151-1002-103J	CB1035	01121	1
A2R2		RESISTOR FIXED,COMP., 2K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-202J	CB2025	01121	1
A2R3		RESISTOR FIXED,COMP., 1K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-102J	CB1025	01121	1
A2R4		RESISTOR FIXED,COMP., 430 OHMS,PORM 5PCT, 1/4W SINGER PART NO. 151-1002-431J	CB4315	01121	2
A2R5		RESISTOR FIXED,COMP., 12 OHMS,PORM 5 PCT, 1/4 W SINGER PART NO. 151-1002-120J	CB1205	01121	1
A2R6		SAME AS A2R4			
A2T1		TRANSFORMER	132-0265-001	16665	1
A2T2		TRANSFORMER	132-0266-001	16665	
A3		TRIODE OSCILLATOR ASSY	110-0244-001	16665	1
A3C1	THRU	CAPACITOR, NON-REPLACEABLE PART OF A3			
C3					
A3J1		CONNECTOR, JACK, NON-REPLACEABLE PART OF A3			
A3R1	THRU	RESISTOR, NON-REPLACEABLE PART OF A3			
R3					
A3V1		TRIODE OSCILLATOR, NON-REPLACEABLE PART OF A3			
A4		TEE FREQUENCY SELECTIVE ASSY	134-0020-001	16665	1
A4C1		CAPACITOR, NON-REPLACEABLE PART OF A4			
A4J1		CONNECTOR, JACK, NON-REPLACEABLE PART OF A4			
A4L1		COIL, NON-REPLACEABLE PART OF A4			
A4P1		CONNECTOR, PLUG, NON-REPLACEABLE PART OF A4			
A5		160 MHZ PREAMPLIFIER	103-1594-001	16665	1
A5C1		SAME AS A2C1			
A5C2		CAPACITOR, VARIABLE, 7 TO 25 PF SINGER PART NO. 150-0008-004	538-01187-25	72982	1
A5C3		SAME AS A2C4			
A5C4	AND	SAME AS A2C1			
C5					
A5FL1	AND	SAME AS A2FL1			
FL2					
A5J1		CONNECTOR, JACK SINGER PART NO. 556146-927	6049	91737	1
A5J2		SAME AS A2J2			
A5L1		INDUCTOR, SHIELDED, 0.22 UH SINGER PART NO. 556200-001	DINK 0.22	78526	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5L2	INDUCTOR	132-0260-001	16665	1
A5L3	INDUCTOR	132-0262-001	16665	1
A5G1	SAME AS A2G1			
A5R1	RESISTOR FIXED, COMP., 15 OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-150J	CB1505	01121	1
A5R2	RESISTOR FIXED, COMP., 120 OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-121J	CB1215	01121	0
A5R3	SAME AS A2R1			
A5R4	SAME AS A2R2			
A5R5	SAME AS A2R3			
A5R6	SAME AS A2R4			
A5R7	SAME AS A2R5			
A5R8	SAME AS A2R4			
A5T1	TRANSFORMER	132-0266-001	16665	1
A6	LEVEL AMPLIFIER ASSY	103-1576-001	16665	1
A6CR1	SEMICONDUCTOR DEVICE, DIODE SINGER PART NO. 556146-195	1N4514	81349	1
A6C1	CAPACITOR, FIXED, CERAMIC DISC, 0.01 UF, PLUS	DA140-172B	71590	1

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
C5	CAPACITOR, FIXED, ELECTROLYTIC, 2.2UF, 35V SINGER P/N 556146-506	CS13BF225K	06751	1
R12	RESISTOR, FIXED, COMP., 10K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-103J	CB1035	01121	1
R13	RESISTOR, FIXED, COMP., 1.5K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-152J	CB1525	01121	1
R14	RESISTOR, FIXED, COMP., 33K OHMS, PORM 5 PCT, 1/4W SINGER P/N 151-1002-333J	CB3335	01121	1
A6	LEVEL AMPLIFIER ASSY	103-1576-002	16665	1
A2R1	SAME AS R12			
A5R3	SAME AS R12			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A8C2	CAPACITOR, FIXED, CERAMIC, 1000 PF SINGER PART NO. 556147-005	8-16-102W	01121	1
A8C4	CAPACITOR, FIXED, CERAMIC, 470PF, PORM 20 PCT, 100V SINGER PART NO. 556147-002	390-000-X5U0471M	72982	1
A8C5	CAPACITOR, VARIABLE, 0.8 TO 4.5 PF SINGER PART NO. 556147-001	560-013	72982	1
A8FL1 FL3	THRU SAME AS A2FL1			
A8J1	SAME AS A2J2			
A8J2	SAME AS A5J1			
A8L1	COIL, RF	132-0283-001	16665	1
A8Q1	TRANSISTOR SINGER PART NO. 556147-003	2N4427	02735	1
A8R1	RESISTOR FIXED, COMP., 240 OHMS, PORM 5 PCT 1W SINGER PART NO. 151-1004-241J	682415	01121	U
A8R2	RESISTOR FIXED, PREC., 292.4 OHMS, PORM 1 PCT, 1/10W SINGER PART NO. 556204-024	DC1/10-292.4 1PCT-NH	91637	1
A8R3	1/10W SINGER PART NO. 556204-003	DC1/10-17.6 1PCT-NH	91637	1
A8R4	SAME AS A8R2			
A8R5	RESISTOR, TEMPERATURE, SENSITIVE, 3.3K, PORM 10 PCT. SINGER PART NO. 556147-011	TM1/4, 3.3K	01295	1
A8T1	TRANSFORMER, 50 TO 12.5 OHMS	132-0277-001	16665	1
A8T2	TRANSFORMER, 200 TO 50 OHMS	132-0278-001	16665	1
A8T3	TRANSFORMER 50 TO 12.5 OHMS	132-0282-001	16665	1
A9	TRIPLER OSCILLATOR ASSY	103-1580-001	16665	1
A9FL1 FL2	AND SAME AS A2FL1			
A9J1	CONNECTOR, JACK SINGER PART NO. 556146-968	6022	91737	1
A9A1	OSCILLATOR ASSY	103-1573-001	16665	1
A9A1C1	CAPACITOR FIXED, DIPPED MICA, 20PF PORM 5PCT 500V SINGER PART NO. 150-2002-200EJD	DM15E200J0500WV4CR	72136	1
A9A1C3	CAPACITOR, FIXED, CERAMIC DISC, 470PF, 1000V SINGER PART NO. 556146-695	DD471	71590	1
A9A1C4	CAPACITOR, VARIABLE, 2 TO 8 PF SINGER PART NO. 150-0008-001	538-011A2-8	72982	1
A9A1C5	CAPACITOR, FIXED, DIPPED MICA, 15 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-150EJD	DM15E150J0500WV4CR	72136	1
A9A1C6	SAME AS A9A1C3			
A9A1C7	CAPACITOR, FIXED, DIPPED MICA, 39 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-390EJD	DM15E390J0500WV4CR	72136	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A9A1C8	SAME AS A2C1			
A9A1C9	CAPACITOR, VARIABLE, 9 TO 35 PF SINGER PART NO. 150-0008-008	538-01109-35	72982	1
A9A1C10	SAME AS A9A1C3			
A9A1L2	SAME AS A5L1			
A9A1Q1	TRANSISTOR SINGER PART NO. 556146-251	2N3563	INSTD	1
A9A1Q2	TRANSISTOR SINGER PART NO. 556146-702	2N3642	79089	
A9A1R1	RESISTOR FIXED, COMP., 430 OHMS, PORM 5 PCT, 1/4w SINGER PART NO. 151-1002-431J	CB4315	01121	1
A9A1R2	RESISTOR FIXED, COMP., 620 OHMS, PORM 5 PCT, 1/4w SINGER PART NO. 151-1002-621J	CB6215	01121	1
A9A1R5	SAME AS A9A1R2			
A9A1R6	RESISTOR FIXED, COMP., 510 OHMS, PORM 5 PCT, 1/4w SINGER PART NO. 151-1002-511J	CB5115	01121	1
A9A1TP1	TEST POINT SINGER PART NO. 556205-001	51-051-0000	98291	1
A9A1T1	TRANSFORMER	132-0257-001	16665	1
A9A1T2	TRANSFORMER, VARIABLE	132-0256-001	16665	1
A9A1Y1	CRYSTAL, 104.167	556146-693	16665	1
A9A2	TRIPLER ASSY	103-1572-001	16665	1
A9A2C1	CAPACITOR, VARIABLE, 2.5 TO 11 PF SINGER PART NO. 150-0008-003	538-01182.5-11	72932	1
A9A2C2	CAPACITOR, FIXED, DIPPED MICA, 56 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-560EJO	DM15E560J0500wV4CR	72136	
A9A2C3	CAPACITOR, FIXED, FEED-THRU, 1000 PF, PORM 20 PCT, 500V SINGER PART NO. 556146-746	2404-000-X500-102P	72982	1
A9A2C4	SAME AS A2C1			
A9A2C5	SAME AS A2C1			
A9A2C6	SAME AS A9A2C3			
A9A2C7	CAPACITOR, FIXED, DIPPED MICA, 18 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-180EJO	DM15E180J0500wV4CR	72136	1
A9A2C8	CAPACITOR, FIXED, DIPPED MICA, 2 PF, PORM 5 PCT 500V SINGER PART NO. 150-2002-2R0EJO	DM15E2R0J0500wV4CR	72136	1
A9A2C9	CAPACITOR, FIXED, DIPPED MICA, 33 PF, PORM 5 PCT, 500V SINGER PART NO. 150-2002-330EJO	DM15E330J0500wV4CR	72136	1
A9A2L1	INDUCTOR	132-0264-001	16665	1
A9A2L2 AND L3	INDUCTOR, SHIELDED, 0.56 UH SINGER PART NO. 556200-003	DINK 0.56	78526	1
A9A2L4	INDUCTOR, VARIABLE	132-0259-001	16665	1
A9A2L5	INDUCTOR, VARIABLE	132-0258-001	16665	1

Section VI
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TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A9A2L6	INDUCTOR	132-0263-001	16665	1
A9A2Q1	TRANSISTOR SINGER PART NO 556146-679	243866	79089	1
A9A2R1	RESISTOR FIXED,COMP., 150 OHMS,PORM 5 PCT, 1/4w SINGER PART NO. 151-1002-151J	CB1515	01121	1
A9A2R2	RESISTOR FIXED,COMP., 2.7 OHMS,PORM 5 PCT, 1/4w SINGER PART NO. 151-1002-2R7J	CB2R75	01121	1
A9A2R3	RESISTOR FIXED,PREC., 11.61 OHMS,PORM 1 PCT, 1/10w SINGER PART NO. 556204-002	DC1/10-11.61 1PCT-NH	91637	1
A9A2R4	RESISTOR FIXED,PREC., 105 OHMS,PORM 1 PCT, 1/10w SINGER PART NO. 556204-017	DC1/10-105 1PCT-NH	91637	1
A9A2R5	SAME AS A9A2R3			



